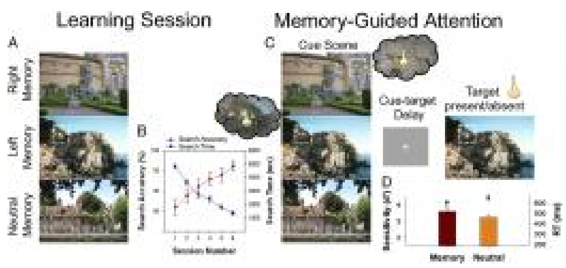
# Remembrance of things future: Long-term memory sets the stage for visual perception

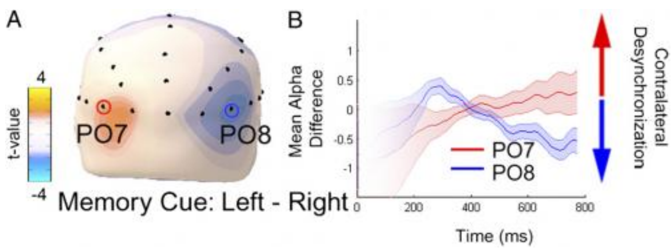
28 December 2011, by Stuart Mason Dambrot




Experimental protocol for memory-guided attention. (A) In both EEG and fMRI experiments, participants first completed a learning task in which they searched for a target stimulus that was embedded within naturalistic scenes. Targets were presented on the right (Right Memory), left (Left Memory) or not at all (Neutral Memory). (B) Over repeated sessions, participants found, and learned, the location of target stimuli. The learning profile from the EEG experiment is plotted for search accuracy (left y axis, red) and search time (right y axis, blue) as a function of training session number (x axis). (C) On the following day, participants performed an attention task in which scenes from the initial learning task were used to cue the location of a subsequent target. The first scene was always presented without the target stimulus, whereas the second scene contained a target on 50% of trials. On target-present trials, previously learned locations were 100% predictive of the subsequent target location. Consequently, valid memory cue scenes could be used to predict the precise location of the subsequent target, whereas memories for neutral cues contained no task-relevant spatial information. (D) Behavioral data are shown for the EEG experiment, with sensitivity (left y axis, bars) and RT (right y axis, triangles) plotted as a function memory condition (memory vs. neutral). Detection sensitivity was higher for spatially predictive memories, and RTs were shorter. Error bars represent ±1 SEM. Copyright © PNAS, doi: 10.1073/pnas.1108555108

(Medical Xpress) -- Rather than being a passive state, perception is an active process fueled by predictions and expectations about our environment. In the latter case, memory must be a fundamental component in the way our brain generates these precursors to the perceptual experience – but how the brain integrates long-term memory with perception has not been determined. Recently, however, researchers in the Department of Experimental Psychology at the University of Oxford, by devising a method for integrating memory and attention, showed how LTM optimizes perception by varying brain states associated with anticipation of spatial localization in the visual field. The scientists also used fMRI to articulate a neural network involving a number of cortical areas likely to be active in the predictive use of memory in the visual cortex.

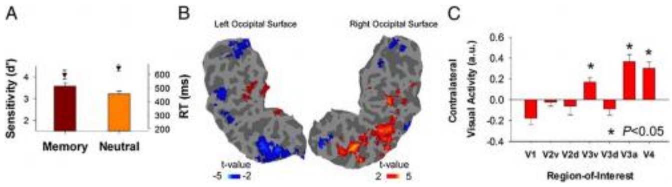
Lead researcher Mark G. Stokes, working with Kathryn Atherton, Eva Zita Patai, and Anna Christina Nobre, explains that to study how memory guides attention, it was first necessary to train each participant of the experiment to remember a large number of associations that can then be used to guide attention. "In this study," Stokes tells *Medical Xpress*, "we exploited the brain's inherent ability to remember specific spatial locations within natural scenes. Despite the enormous visual complexity in such scenes, the brain is extremely adept at processing this kind of information, and can store essential details in long-term memory with little apparent effort. This ability is an ideal route for us to experimentally manipulate the contents of long-term memory to test the effects of attention on visual performance, and explore the underlying brain basis with EEG and fMRI."




Memory predictions trigger contralateral alpha-desynchronization in posterior electrodes. (A) EEG recordings demonstrate that memory cues trigger spatially specific desynchronization of alpha-band oscillations in posterior electrodes, including PO7/PO8. The scalp topography of cue-specific differences (left ? right cue; 650-750 ms) in alpha power is shown projected across a 3D scalp surface. (B) Time-course analysis of alpha power in lateralized posterior electrodes, PO7 (in red) and PO8 (in blue), illustrates how contralateral desynchronization emerges at approximately 400 ms after the cue onset. Positive values reflect contralateral desynchronization in the left hemisphere, whereas negative values reflect desynchronization in the right hemisphere, and shading represents ±1 SEM. Copyright © PNAS, doi:10.1073/pnas.1108555108

To accomplish this, says Stokes, the key methodological development in their research was to specifically measure how long-term memories modulate preparatory brain activity. “For the fMRI experiment, this involved a technique called event-related fMRI, which allows us to separate statistically the brain response to distinct cognitive events. Incorporating high-temporal resolution EEG was also a key innovation in this research, providing a more direct real-time measure of memory related changes in preparatory brain activity.”

The next step in the team’s research was to determine how an integrated circuit of attention and memory related brain areas – the frontoparietal cortex, and hippocampus, respectively – are coordinated for memory-guided attention. “So far we’ve demonstrated which brain areas are active,” Stokes notes, “but more detailed imaging data could also tell us how these areas communicate. Moreover, disruption methods like Transcranial Magnetic Stimulation can pinpoint which nodes of the frontoparietal network are necessary for memory guided attention.”




Memory predictions increase BOLD-related activity in contralateral visual areas. (A) Behavioral analysis of fMRI experiment confirmed that detection sensitivity was enhanced for targets presented at memory-predicted locations, relative to memory-neutral locations. Detection sensitivity (left y axis, bars) and RT (right y axis, triangles) are plotted as a function memory condition (memory valid vs. neutral). (B) Analysis of the BOLD response revealed evidence of spatially specific biases in preparatory visual activity: memory cues elicited increased activity in contralateral subregions of visual cortex, particularly in extrastriate visual areas. Data contrasting left vs. right views are shown on the occipital surface, extracted and flattened using Freesurfer (Materials and Methods) (C) Spatially specific cue-related activity is shown for specific visual areas (text provides details). Error bars represent ±1 SEM. Copyright © PNAS, doi:10.1073/pnas.1108555108

Commenting on how their findings might impact other areas, Stokes points out that integrating high-spatial resolution fMRI and high-temporal resolution EEG would be a powerful approach for a range of cognitive neuroscience applications. It also might be possible, Stokes agrees, to transition to a completely in silico model based on optogenetics-derived data.

**More information:** *Long-term memory prepares neural activity for perception*, *PNAS*, Published online before print November 22, 2011, doi: 10.1073/pnas.1108555108

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