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OSCILLATIONS

Synchrony shows mice the way

The function of neuronal oscillations has intrigued neuroscientists over the past 20 years. Gamma oscillations have been proposed to have a role in memory, perception and attention, but no studies have shown a causal role for gamma oscillations in these processes. Tonegawa and colleagues now provide evidence that synchronized, high-frequency gamma oscillations (HFGOs) contribute to successful decision making in a working-memory task in mice.

Previous studies had demonstrated, in mice performing a spatial working-memory task, that the local field potential (LFP) shows phase-locked theta and gamma oscillations between the medial entorhinal cortex (MEC) and the hippocampal CA1 area. The authors set out to investigate whether and how these oscillations — and HFGOs in particular — contribute to working-memory performance in mice.

The experiments involved a spatial working-memory task with alternating 'sample trials' and 'test trials'. In sample trials, mice were placed on the central arm of a T maze. One of the other two ('reward') arms was blocked so that the mice had to enter the remaining arm to retrieve a food reward. In test trials, both reward arms were open, and mice now had to enter the previously closed arm to retrieve the reward. Thus, in test trials, mice had to remember which arm had been closed in the preceding sample trial — this was the working-memory component.

The authors first showed that the occurrence and power of transient bursts of HFGOs (called high-gamma incidents (HGIs)) were particularly high just before mice reached the maze junction in test trials. LFP recordings revealed that HGIs in the MEC and CA1 became synchronized (sHGIs) as mice approached the maze junction — specifically, ~350 ms before turning into the reward arm — in correctly performed test trials but not in incorrect test trials or sample trials. Occasionally, mice would first enter the incorrect arm, turn around and then enter the correct one; these were called 'oops trials'. Interestingly, in these trials, the sHGIs with the highest synchrony occurred not as the mice reached the junction, but ~200 ms before the mice changed direction on the incorrect arm.

Multiunit recordings showed that the pattern of spiking-activity bursts in the MEC and CA1 (in which multiunit activity was phase-locked to local theta oscillations and to HFGOs, respectively) in correct, incorrect and oops trials matched that of sHGIs. This pattern suggested that sHGIs may reflect recall of information in working memory about the previously entered arm.

Investigating whether sHGIs were indeed required for correct performance on the spatial working-memory task, the authors used optogenetic manipulation to inhibit the inputs from the MEC to CA1 — and, thereby, the occurrence of sHGIs — in mice that had been trained on the maze. Light delivery while mice approached the maze junction decreased the number of sHGIs, reduced theta-locked spiking bursts in the MEC and reduced the number of correct test trials by 50%. By contrast, light delivered to mice at other points on the maze or in sample trials had no effect.

These findings show that bursts of sHGIs precede — and thus predict — an animal's correct choice in a spatial working-memory task, and this suggests that they may reflect content in working memory entering the animal's 'awareness'.

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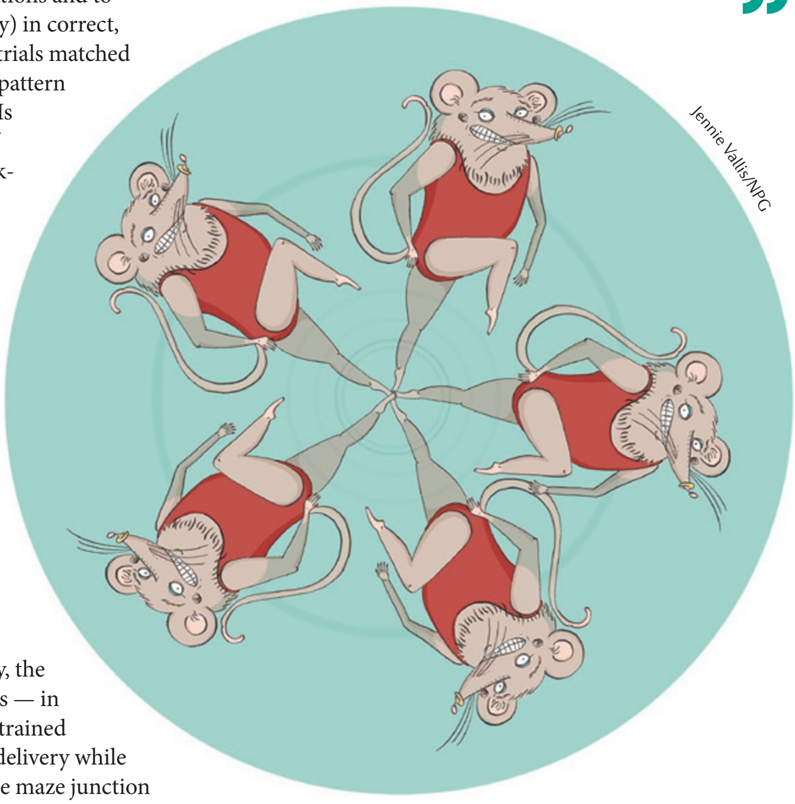
ORIGINAL RESEARCH PAPER Yamamoto, J. *et al.* Successful execution of working memory linked to synchronized high-frequency gamma oscillations. *Cell* http://dx.doi.org/10.1016/j.cell.2014.04.009 (2014)



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