Research in the role of theta oscillations on learning on memory go back to the late 70s (Winson, 1978, Berry and Thompson, 1978). Winson (1978 xx) showed that lesioning the medium septum caused impaired spatial memory along with a reduced hippocampal theta rhythm. In line with this, higher theta power in rabbits was associated with augmented learning (Berry and Thompson, 1978).

More recent findings in humans demonstrated that later recalled items are associated with a higher theta power in comparison to later forgotten items (Lega, Jacobs, Kahana, Hippocampus, 2012; Staudigl & Hanslmayr curr biol 2013; Kahana et al., nature 1999 <- all from tW). Another piece of evidence for the importance of theta in the memory process comes from ter Wal and colleagues who showed that the behavioural response time during memory retrieval is modulated by a theta rhythm (ter Wal et al., 2021 nat coms xx).

The formation of episodic memories requires the integration of multiple different elements (Tulving xx) that are represented in different modalities across the cortex (check out Konkel & Cohen 2009 and wallenstein, Eichenbaum & Hasselmo 1998). It is thought that hippocampal theta activity works to bind the different elements that make up an episodic memory (Griffiths et al., 2021 doi.org/10.1016/j.neuroimage.2021.118454).

These multi-modal elements are thought to bind together by long-term potentiation of synaptic connections - a process which is sensitive to the exact timing of neural firing [Markram Lübke, Frotscher, & sakmann, 1997 xx]. In humans, this timing is suggested to depend on hippocampal theta activity (Clouter, 2017 xx, check out hanslmayr staresina bowmann 2016 and the staresina wimber paper, also Buzsáki, G. Theta oscillations in the hippocampus. *Neuron* **33**, 325–340 (2002); In line with this the theta oscillation has been termed a “temporal organizer” (Buzsaki 2005 xx) and faster theta oscillations have recently been shown to synchronize neural firing in the medial temporal lobe during successful encoding of memories (Roux et al., 2022 xx)

A central requirement of the hippocampus is the ability to encode new information without interfering with related previous experiences. Hasselmo and collegues developed a computational model that solves this conundrum by moving encoding and retrieval processes to opposing phases in the theta rhythm (xx, also shapiro turk browne botvinick norman 2017?). Empirical support for this 180° shift between memory encoding and retrieval has been recently found by (Kerrén et al., 2018, current biology, xx). In line with this, later remembered items in an item recognition task were associated with a higher spike-field coupling in the theta band (3-8 Hz) (Rutishauser et al., 2010, nature xx)

This same mechanism of separating conflicting information in different theta phases has been shown in a proactive interference task. Here, after several repetitions the competing association occurred in a separate phase of a 3 Hz theta oscilllation compared to the target association making it less likely to be retrieved (?). This phase offset effect was more pronounced when interference was behaviourally lower (Kerrén et al., biorxiv).

Neurons code information through the theta phase in which they fire (Josh 2007 paper, o'keefe phase precession paper, huxter et al, 2003 <-xx). A stronger spike-field coupling predicts successful memory (rutishauser nature 2010).

We therefore expected neurons in the hippocampus to fire at distinct and separate theta phases during encoding and retrieval of episodic memories.