Sharp-Wave Ripple Complexes Contribute to Context-Dependent Separation of Memories in a Rodent Reconsolidation Task

Stephanie Nagl[1],Lindsey Crown[1], Bethany Jones[2], Masami Tatsuno[4] and Jean-Marc Fellous[1,3]

1: Department of Psychology, University of Arizona, **2.** Psychology, University Massachussets Amherst, 3: Applied Mathematics, 4: Department of Neuroscience, University of Lethbridge

BB77

Introduction

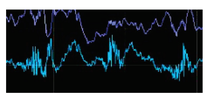
- Reactivation of memories returns them to a labile state, allowing for the alteration and/or updating of memories that were previously consolidated (Jones et al. 2012; Nadel & Land 2000).

- In rodents, neural firing that occurs during a task is replayed during subsequent slow wave sleep (SWS) and this process is involved in memory (re)consolidation (Marshall and Born 2007).

- Replay occurs during **sharp wave/ripple** complexes (SPWs, 150-200 Hz), triggered by CA3 which may allow for spike-timing dependent plasticity (Buzsaki and Draguhn 2004).

- Disruption of these SPWs during sleep leads to memory impairments (Girardeau 2009 et al., 2009; Ego-Stengel and Wilson, 2010).

- SPWs have also been implicated in the stabilization of cognitive maps for new environments (Csicsvari and Dupret, 2013).

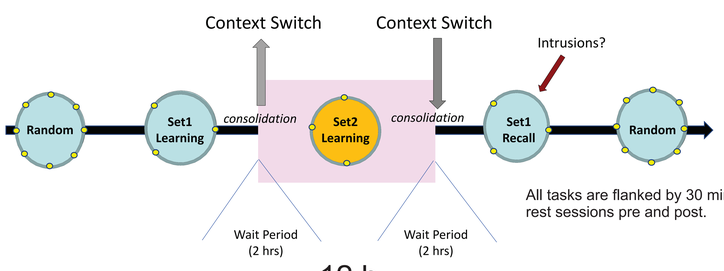


Methods

Rats are implanted with a 14-tetrode “hyperdrive” targeted to right dorsal CA1 area of hippocampus.

The rats learn they will receive a sugar water reward at any of 8 equidistant feeders. During the task only a subset of 3 of these feeders is rewarded (a “Set”).

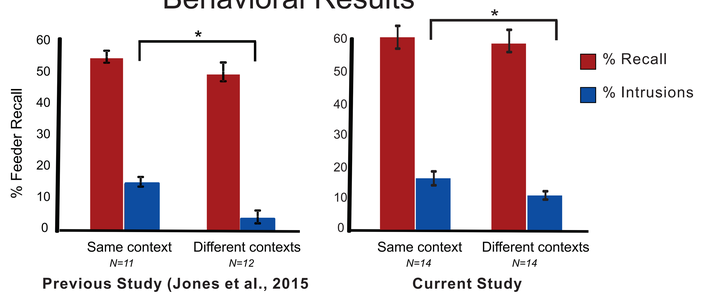
Intrusions are defined as any Set2 feeder visited during Set1 recall.



All tasks are flanked by 30 min rest sessions pre and post.

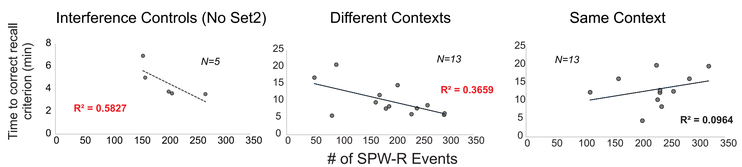
N = 4 adult male Brown Norway Rats
26 experiments (13 “Same Context”, 13 “Different Context”)
307 pyramidal neurons
*: p<0.05

Behavioral Results



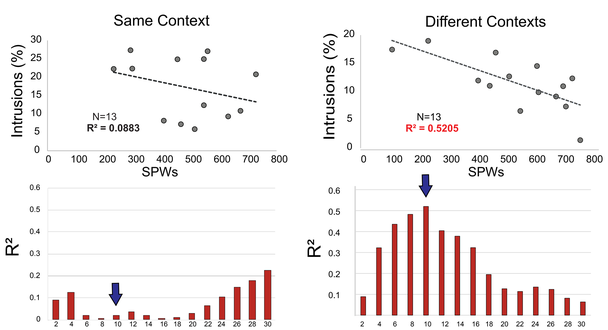
Significantly fewer intrusions were made during Set1 Recall if Set1 and Set2 were learned in different contexts (Jones et al., 2015). Average recall performance was comparable in both conditions.

SPWs and Correct Recall



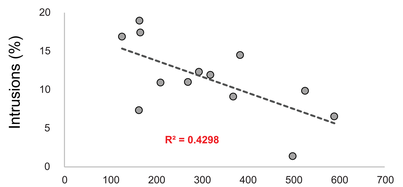
Post Set1 SPW event frequency correlates more with recall performance when there are fewer opportunities for interference between learning and test. This effect is most apparent in the first 5min post Set1 rest.

SPWs and Intrusions



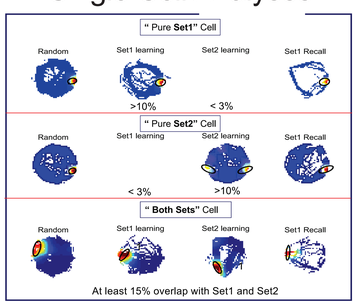
SPWs immediately after Set2 learning show a significant ($p<0.05$) negative correlation with intrusions during Set1 Recall, but only in different contexts condition.

SPWs and Context



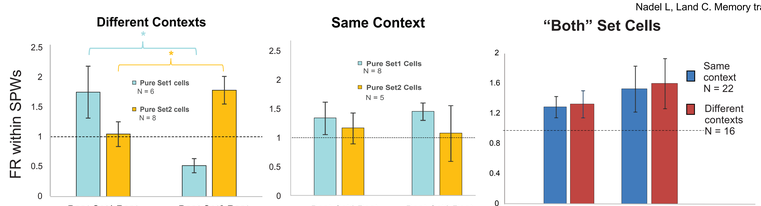
The negative correlation between SPWs and intrusions emerges ***before*** Set2 learning, beginning 20 min after first exposure to the new context.

Single Cell Analyses



“Pure” Set cells are stable across entire experiment, but fire almost exclusively in one Set and not the other (<3%). May represent place fields specific to a feeder location.

Firing Rate within SPW Events - Normalized to First Pre-Rest Session



In Different contexts, Pure Set1 cells and Pure Set2 cells have an increased FR after Set1 and Set2 learning respectively. Interestingly, Pure Set1 cells have lower than control FR following Set2 learning. In contrast, in the Same context condition, Pure Set1 and Pure Set2 cells have similar FR within SPWs irrespective of the learning epochs.

Cells that showed similar FR in both Sets also showed similar FR within SPWs for both Post-Rest sessions, regardless of the experimental condition.

Conclusions and Interpretations

- SPWs show a similar time-course in relation to replay following a task as previously reported (Kudrimoti et al., 1999).

- SPW event frequency immediately following learning is correlated with the amount of intrusions that a rat will make during recall up to 4 hours later, but only in the Different Contexts condition.

- SPWs immediately following Set1 learning are more correlated with correct recall of Set1 when there are fewer opportunities for interference between learning and test.

- Place cells that fire nearly exclusively during Set1 learning show a decreased firing rate in SPW events following Set2 learning in the Different Contexts condition only.

- Reactivation of Set1 cells following Set2 learning in the Same Context condition may be a consequence of context-induced reconsolidation.

- Failure of Set1 cells to decrease their firing rate following Set2 learning in the same context may be a mechanism leading to higher intrusion rates.

- Our results are in agreement with the idea that SPWs contribute to the stabilization of new contextual maps, allowing for the improved binding of important information with context (Csicsvari 2013).

References

Csicsvari J, Dupret D. Sharp wave/ripple network oscillations and learning- associated hippocampal maps. Philos Trans R Soc Lond B Biol Sci. 2013 Dec 23;369(1635):20120528.

Ego-Stengel V, Wilson MA. Disruption of ripple-associated hippocampal activity during rest impairs spatial learning in the rat. Hippocampus. 2010 Jan;20(1):1-10.

Girardeau G, Benchenane K, Wiener SI, Buzsáki G, Zugaro MB. Selective suppression of hippocampal ripples impairs spatial memory. Nat Neurosci. 2009 Oct;12(10):1222-3.

Jones B, Bukoski E, Nadel L, Fellous JM. Remaking memories: reconsolidation updates positively motivated spatial memory in rats. Learn Mem. 2012 Feb 17;19(3):91-8.

Kudrimoti HS, Barnes CA, McNaughton BL. Reactivation of hippocampal cell assemblies: effects of behavioral state, experience, and EEG dynamics. J Neurosci. 1999 May 15;19(10):4090-101.

Marshall L, Born J. The contribution of sleep to hippocampus-dependent memory consolidation. Trends Cogn Sci. 2007 Oct;11(10):442-50. Epub 2007 Oct 1. Review.

Nadel L, Land C. Memory traces revisited. Nat Rev Neurosci. 2000 Dec;1(3):209-12. Review.

Acknowledgments

Office of Naval Research (N000141310672).
Zachary Trahan, University of Arizona.
Paola Malebra, Univ. of California, Riverside.

Contact Information:
nagl@email.arizona.edu