

Electrophysiological, behavioral, and computational investigations of memory reconsolidation in the rat hippocampus

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Introduction

- Re-exposure to the experimental spatial context can trigger memory reconsolidation in humans (Hupbach et al., 2008) and rodents (Jones et al., 2012).
- Hippocampal place cells represent spatial location, and their activity changes ("remaps") across different spatial contexts.
- The objectives of this study are to observe 1) if objects influence the representation of context, 2) if transient, physiological changes in affective states can act as contexts, and 3) if long term changes in affect, as induced by a PTSD protocol, can influence 'normal' memory reconsolidation.
- We investigate the possible mechanisms underlying the effect of context on memory using a connectionist model of the hippocampus (Greene et al. 2013)

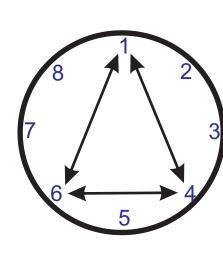
2. Methods

Animals

Male brown norway rats, 8-12 months old.

Behavioral Apparatus

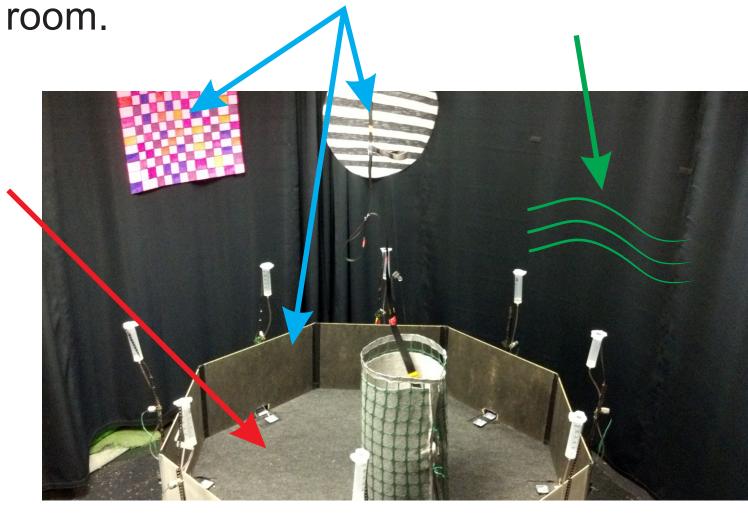
 Open field arena with 8 equally spaced feeders containing sugar water.



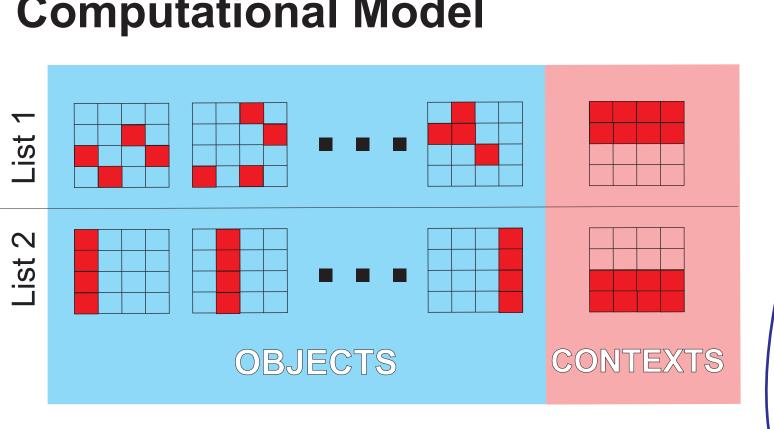
Memory Item= List: 1,4,6 (in no particular order)

Spatial Context

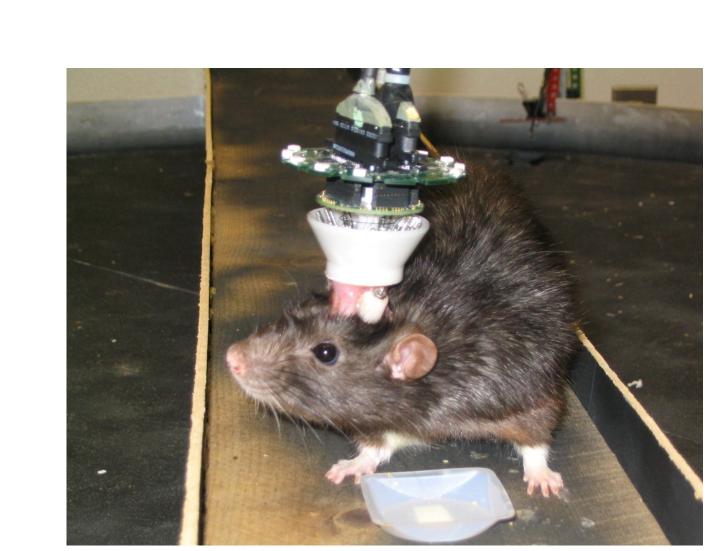
 Novel combinations of odor, texture and visual cues (distal and proximal) in the



Computational Model



- Separate and interacting 'object' and 'context'
- Plastic Hebbian synapses
- Explicit outputs for objects and context
- Lists contain 20 objects, as in the human experiments



Reconsolidation

Induction of Global Remapping

Remapping with Objects

Place Field Anchoring?

N=100

Context A vs. Context B

4. Role of objects on global remapping:

Context B vs. Context A

Remapping Stable

CA1 distal TCA1 proximal CA1 distal CA1 proximal

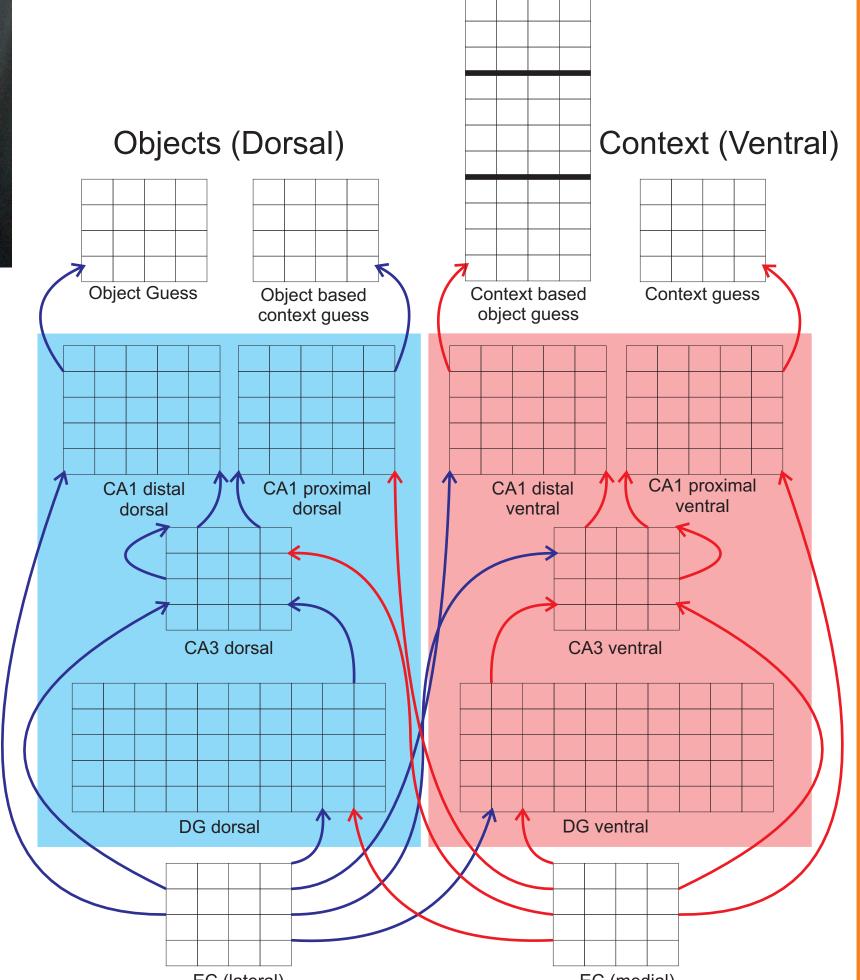
List 3 context C - List 2 context A - List 2 Context A recall - List 3'

CA3 ventral

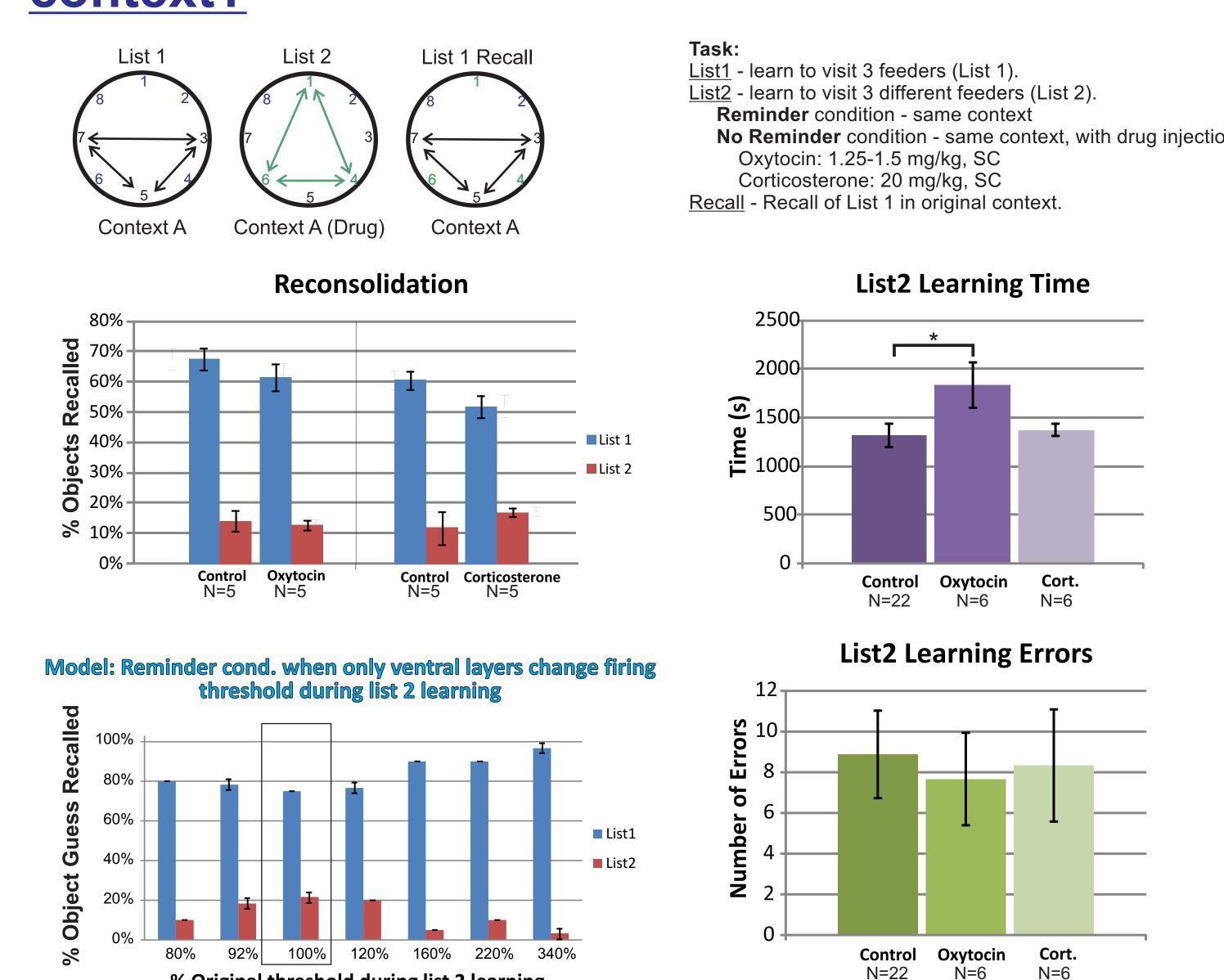
Pre-Shock Post-Shock N=10 N=12

CA3 dorsal

context C' - List 1 context A recall



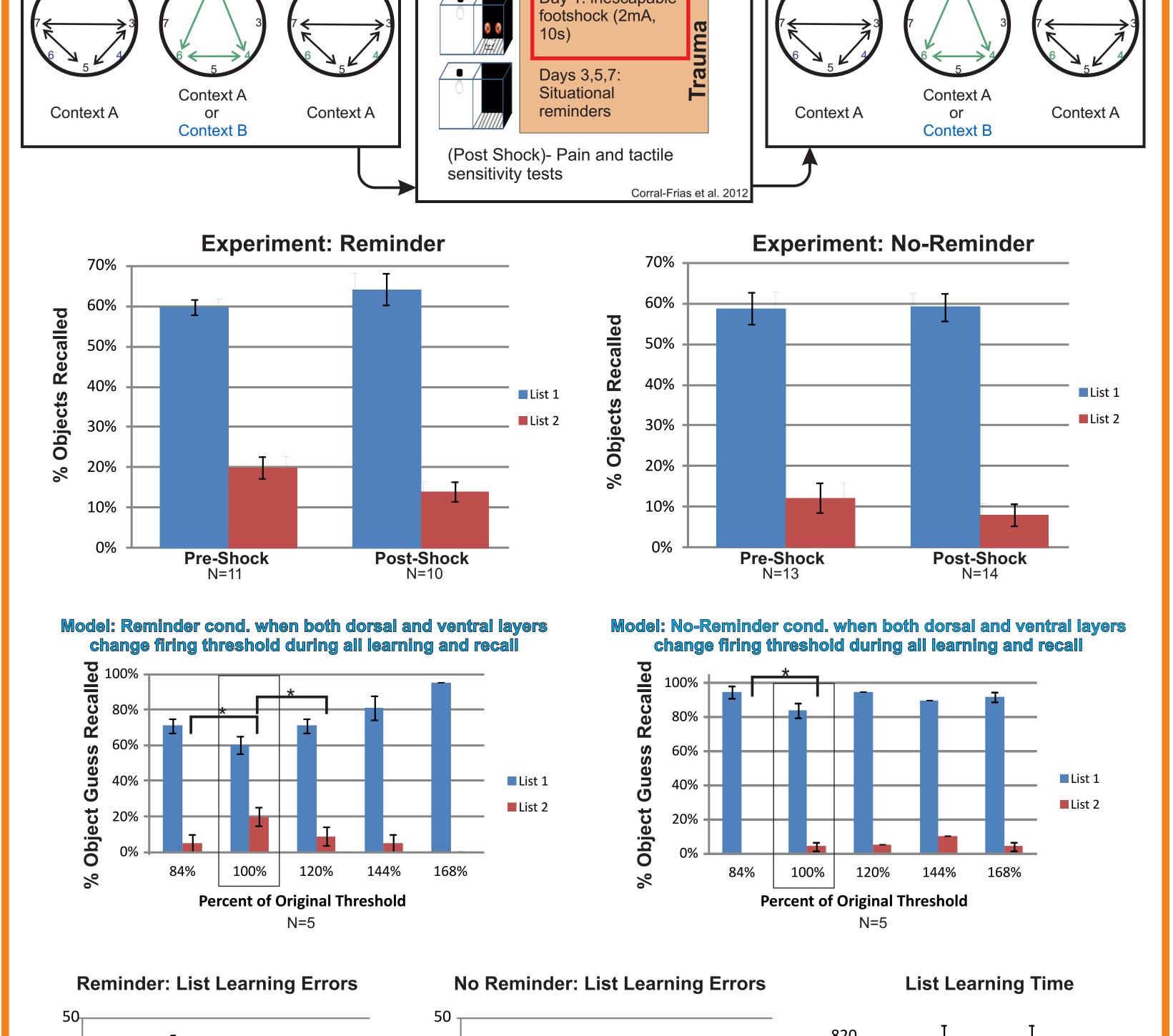
5. Can artificially induced emotional states act as context?



6. PTSD and reconsolidation of non-emotional memories

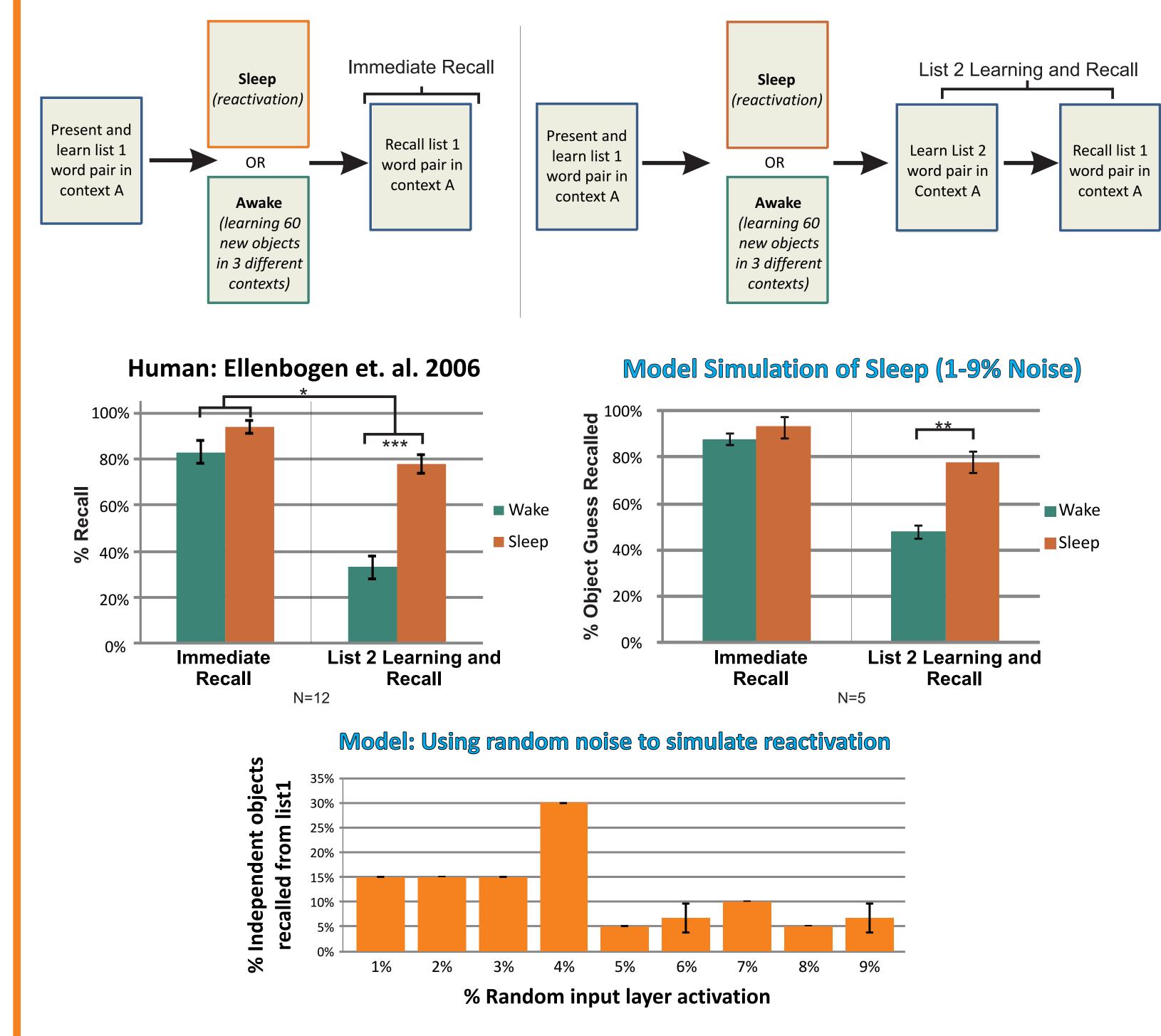
(Pre Shock) - Pain (Tail Flick) and

tactile (Von Frev) sensitivity tests



Pre-Shock Post-Shock N=10 N=14

7. Model of reactivation, sleep and consolidation



8. Conclusions

- Object representation overlap as well as additional, extraneous learning in the model can explain how context affects recall and intrusions in behavioral experiments of memory reconsolidation.
- Objects do not have significant effects on remapping in this task. The model supports this observation.
- The model predicts that changes in the excitability of cells in the ventral layers should decrease memory intrusions. However, the data suggest that transient corticosterone injections during list 2 learning increase the number of intrusions during recall. Oxytocin does not appear to significantly influence reconsolidation, possibly because of its effect during learning.
- Long-term anxiety decreases the number of intrusions upon recall. Changes in the firing threshold in both the dorsal and ventral divisions of the model reduce the number of intrusions.
- Small amounts of noise introduced in the input layers to simulate reactivation during sleep have the effect of consolidating memory, as shown in human data.

9. References

Pre-Shock Post-Shock N=40 N=50

Corral-Frias, Nadia S., et al. "Involvement of the ventral tegmental area in a rodent model of post traumatic stress disorder". Neuropsychopharmacology (2012).

Greene P., Howard M., et al. "Hippocampal anatomy supports the use of context in object recognition: a computational model". Computational Intelligence and Neuroscience. 2013: ID 294878, 2013 Hupbach A, Hardt O, Gomez R, Nadel L. The dynamics of memory: Context-dependent updating. Learning and Memory, 15:574-579 (2008). Hippocampus, 17(3):181-91 (2007).

Jones B, Bukoski E, Nadel L, Fellous JM. Re-making memories: Reconsolidation updates positivelymotivated spatial memory in rats. Learning and Memory, 19(3): 91-98 (2012).

10. Acknowledgements

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