The Influence of Aging on the Variability of Neuronal Activity

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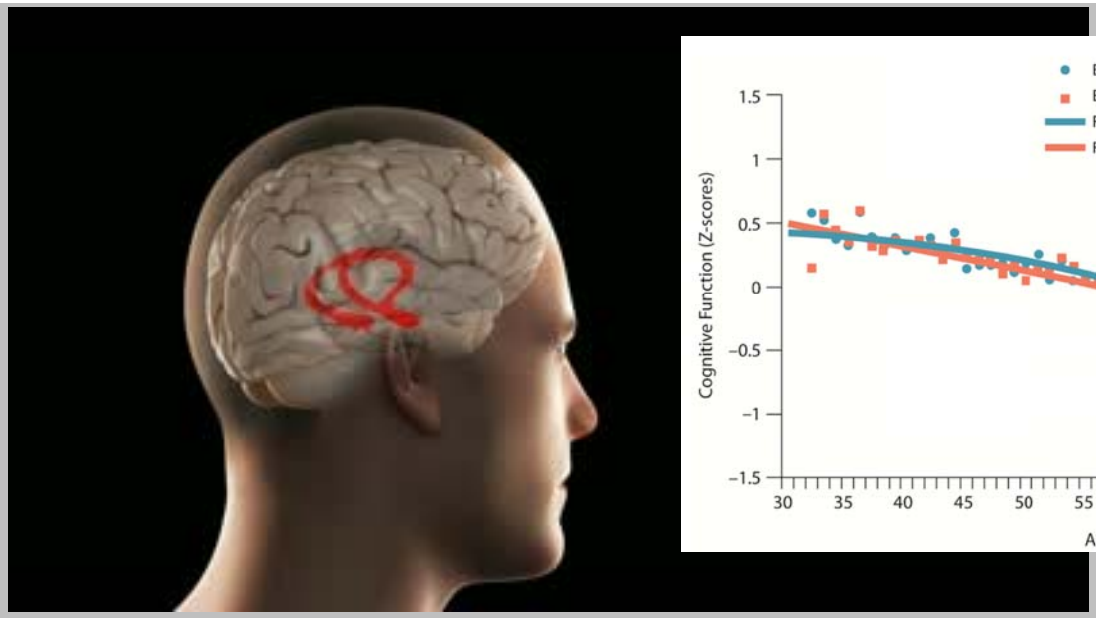
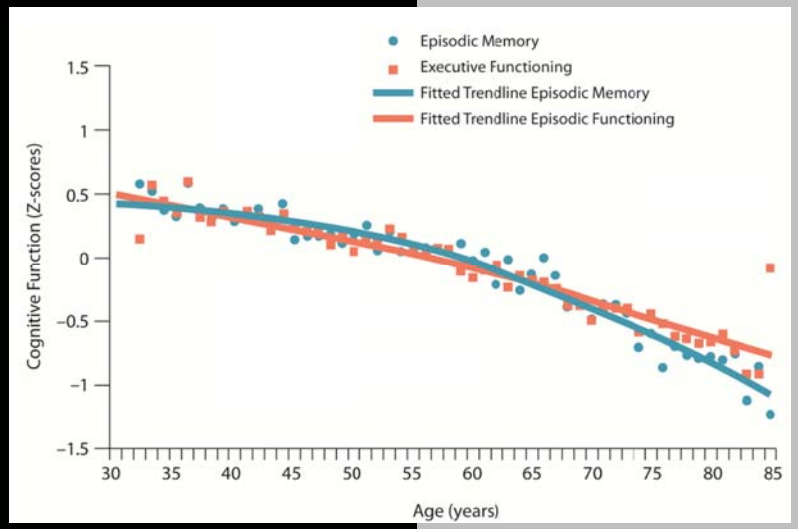
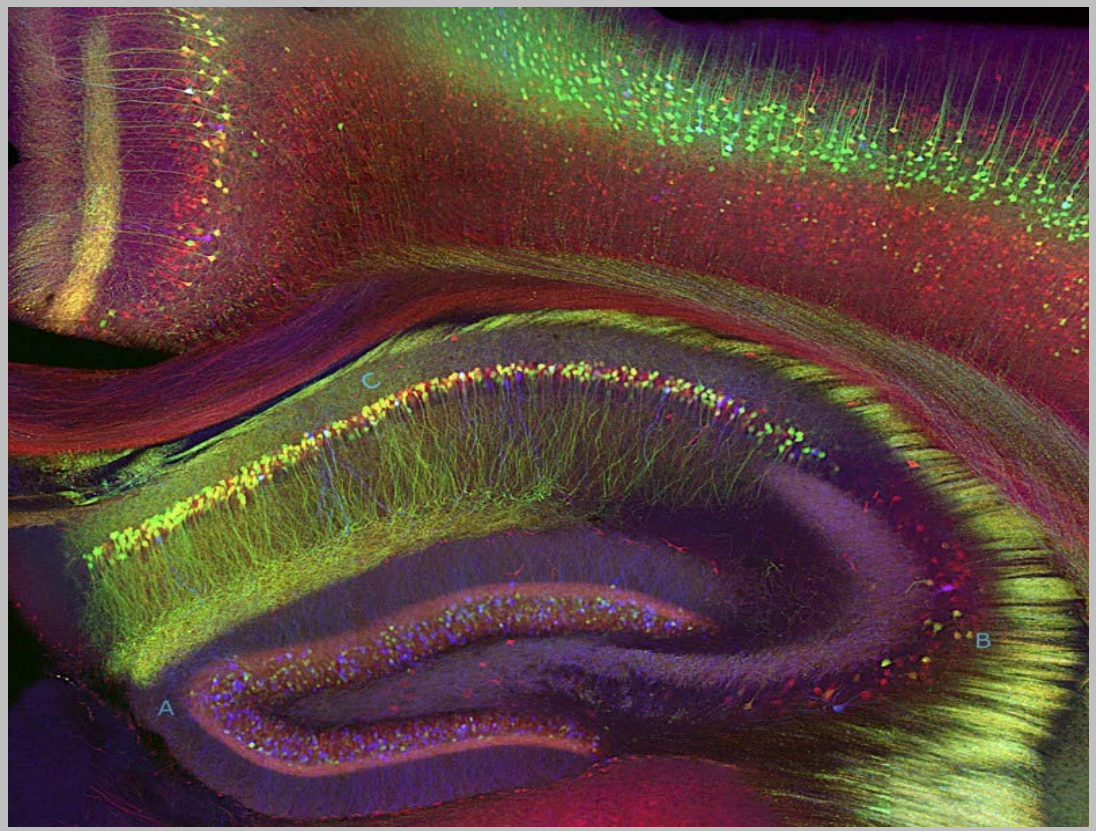
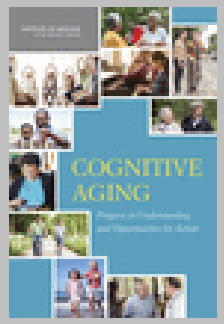


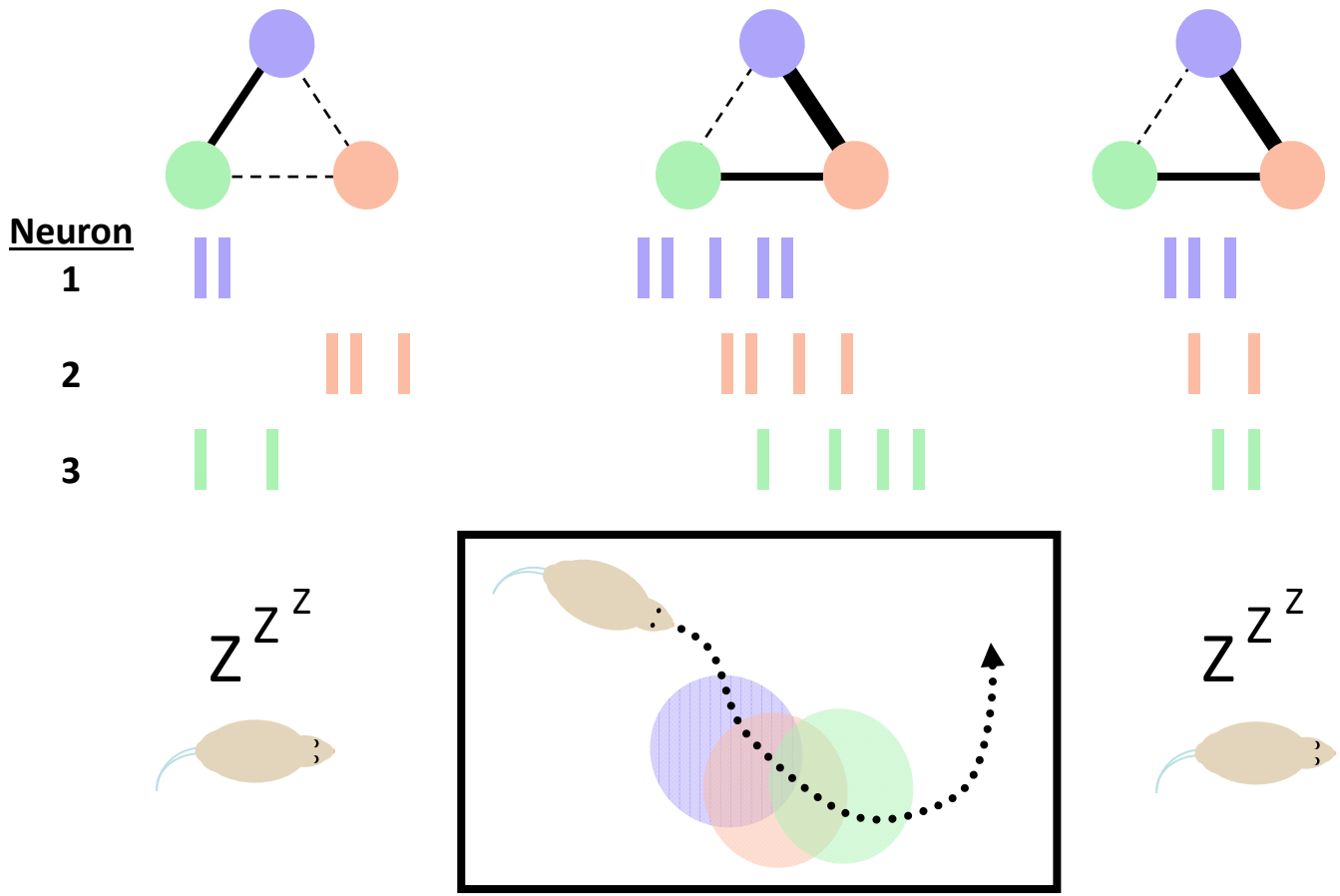

Episodic Memory
Executive Functioning
Fitted Trendline Episodic Memory
Fitted Trendline Episodic Functioning
Cognitive Function (Z-scores)
1.5
1
0.5
0
−0.5
−1
−1.5
30
35
40
45
50
55
60
65
70
75
80
85
Age (years)


C
A
B


COGNITIVE
AGING

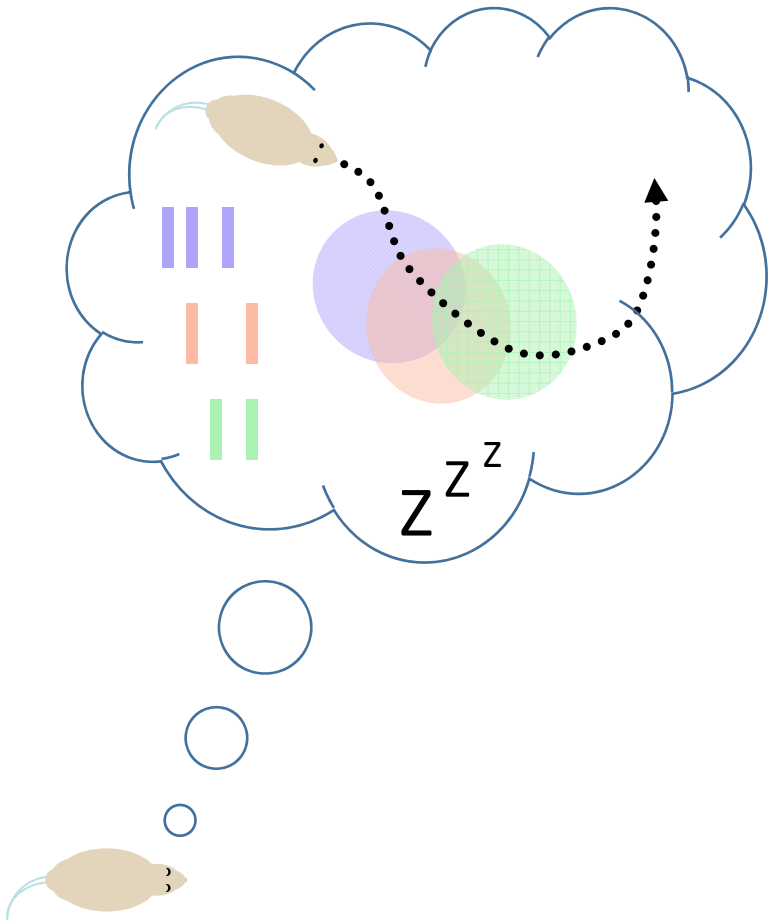

Less of it
Phase advance
Intermittent waking
Critical for the consolidation of episodic memories

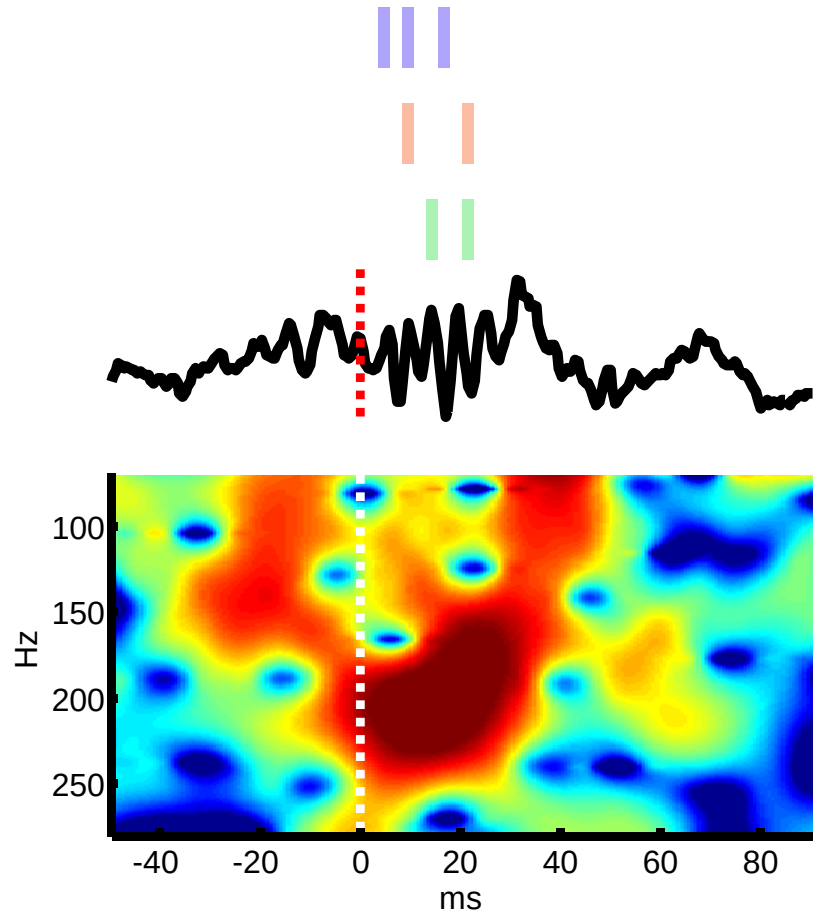
Episode-like information is re-played in the hippocampus during sleep



Wilson, M. A., & McNaughton, B. L. B. (1994). Reactivation of hippocampal ensemble memories during sleep. *Science*, *5*(14), 5–8.

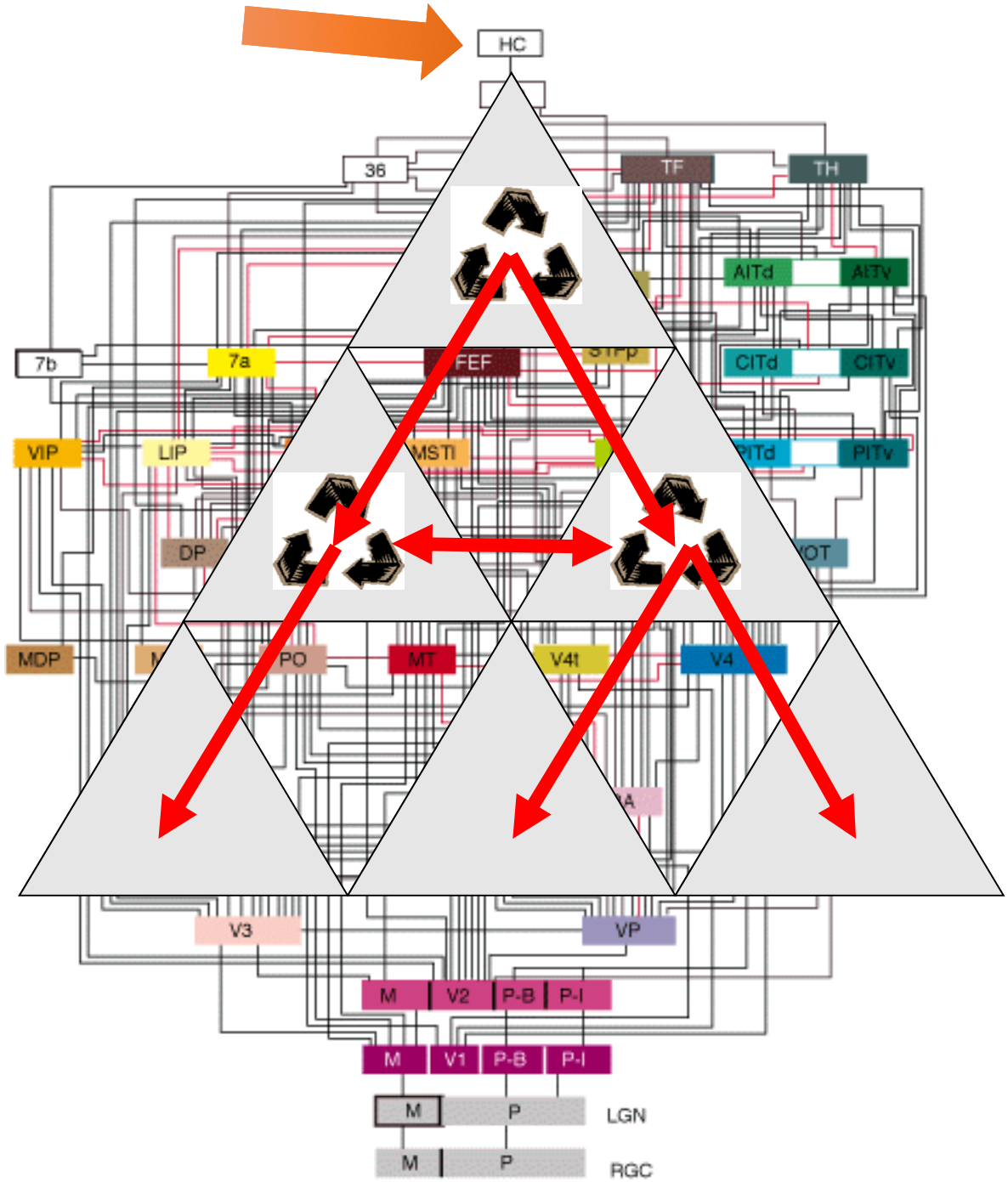
This “reactivation” occurs mostly during ripple oscillations



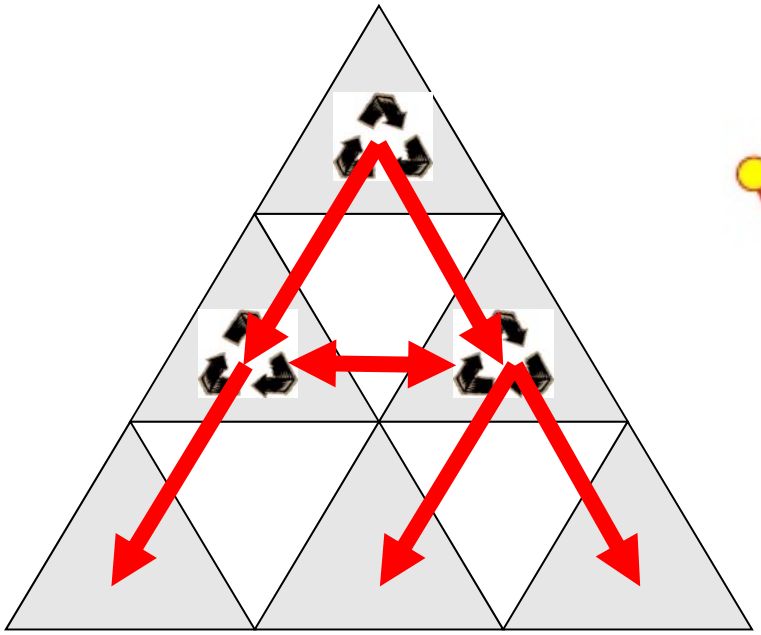


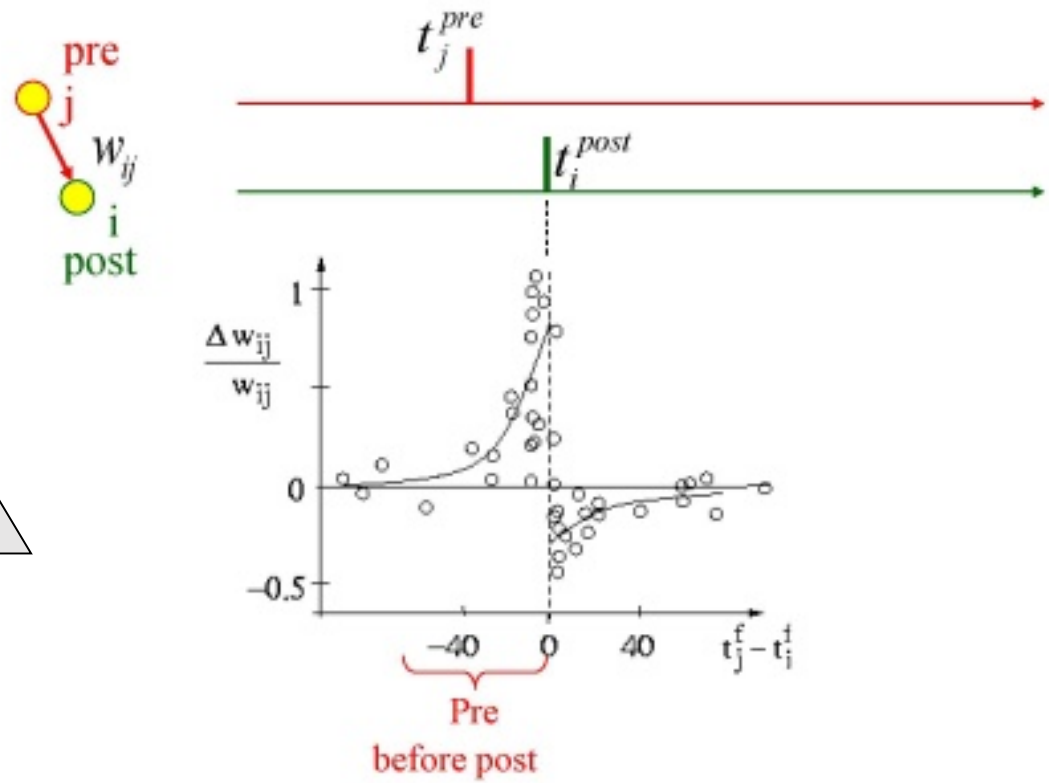
Kudrimoti, H. S., Barnes, C. A., & McNaughton, B. L. (1999). Reactivation of hippocampal cell assemblies: effects of behavioral state, experience, and EEG dynamics. *J Neurosci*, *19*(10), 4090–101.

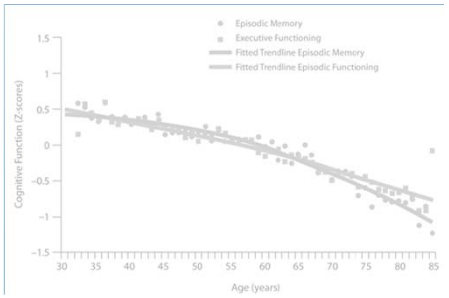
Theory


HC
36
TF
TH
AITd
AITv
7b
7a
FEF
CITd
CITv
VIP
LIP
MSTl
PITd
PITv
DP
MDP
PO
MT
V4t
V4
V3
VP
M
V2
P-B
P-I
M
V1
P-B
P-I
M
P
LGN
M
P
RGC

Reduced neuronal reliability could impair this process…

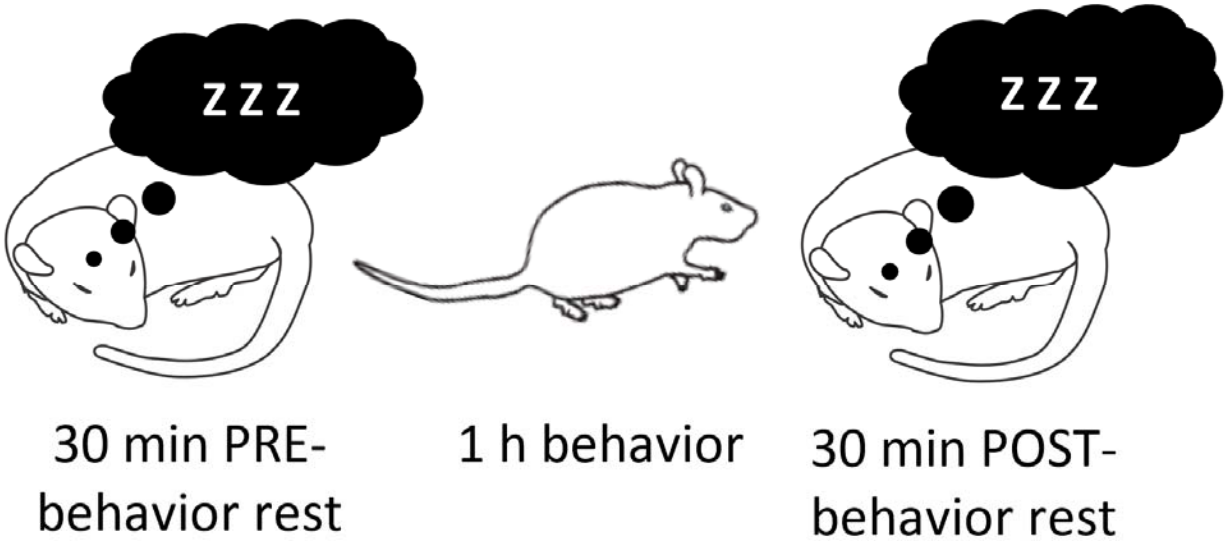




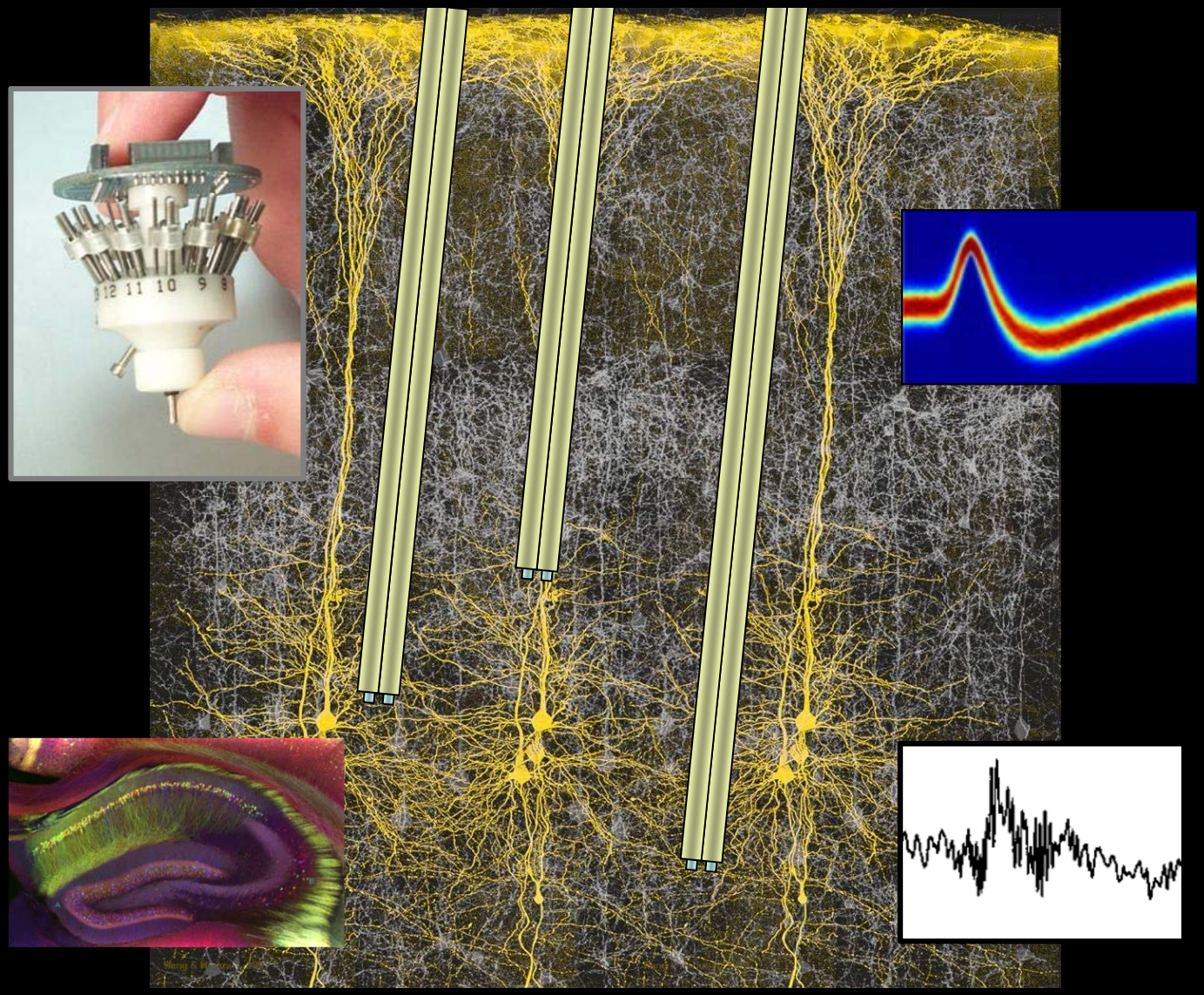


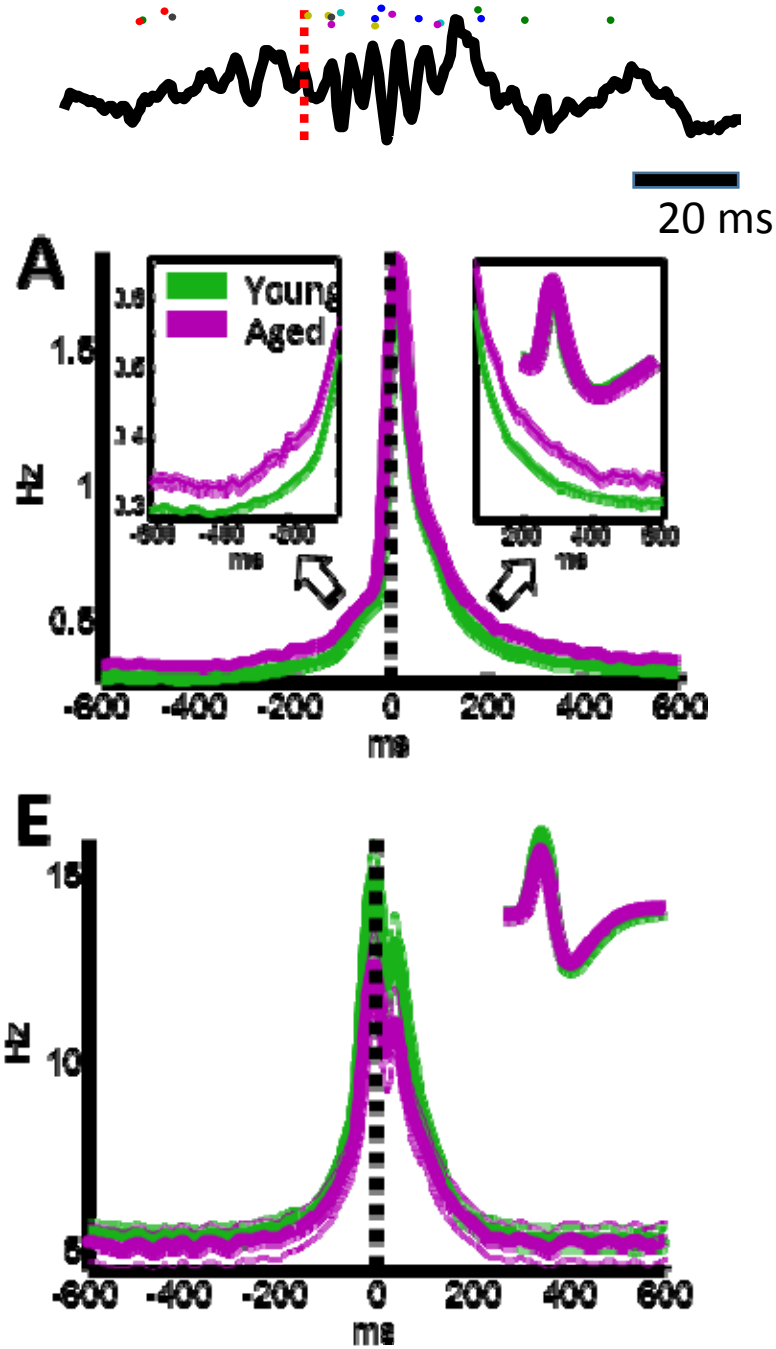
Given that aging is associated with reduced capacity to encode and recall episodic memories…

General Hypothesis: Ripple-associated neuronal activity will be associated with more variability.



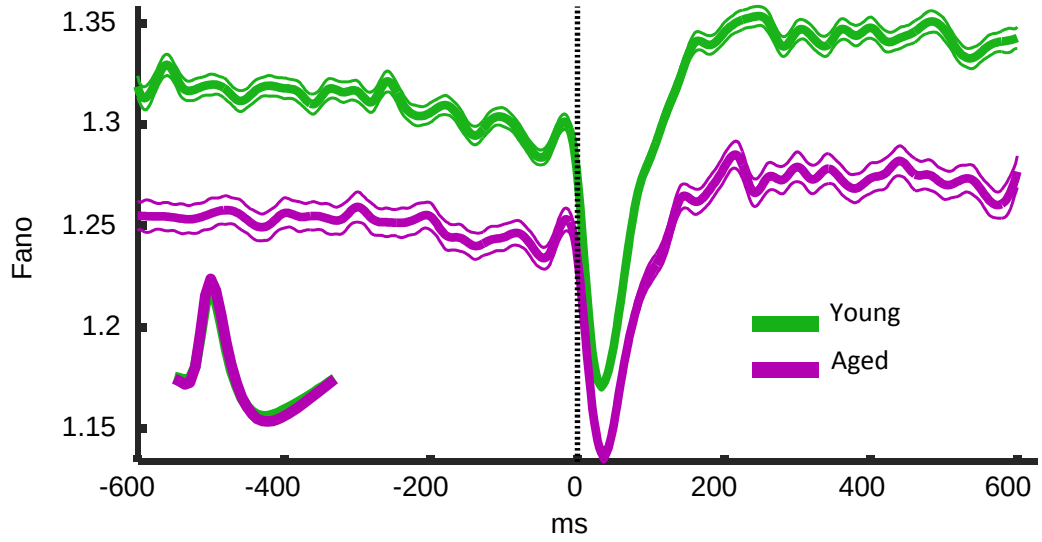
Schimanski, L. a, Lipa, P., & Barnes, C. a. (2013). Tracking the course of hippocampal representations during learning: when is the map required? *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience*, *33*(7), 3094–106.

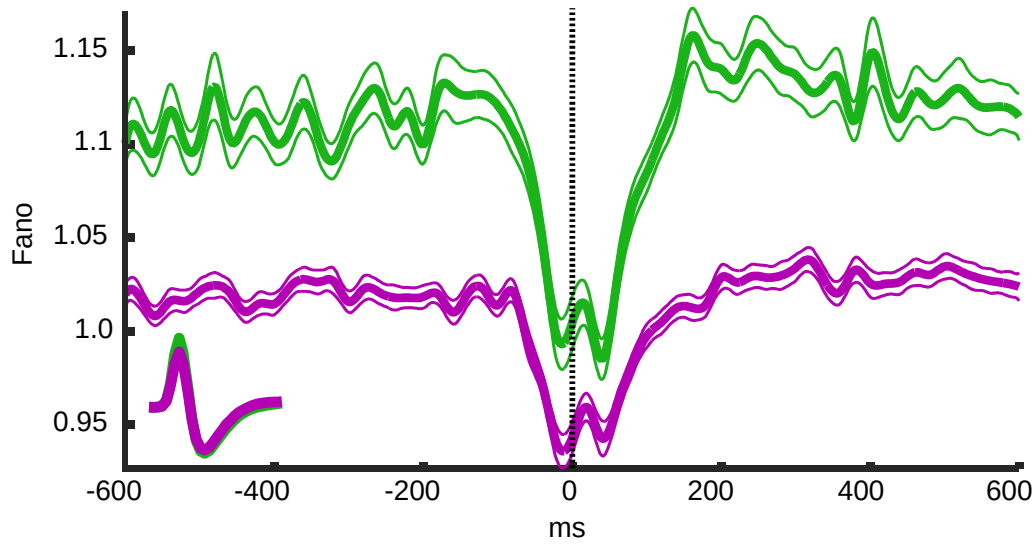

12 11 10 9

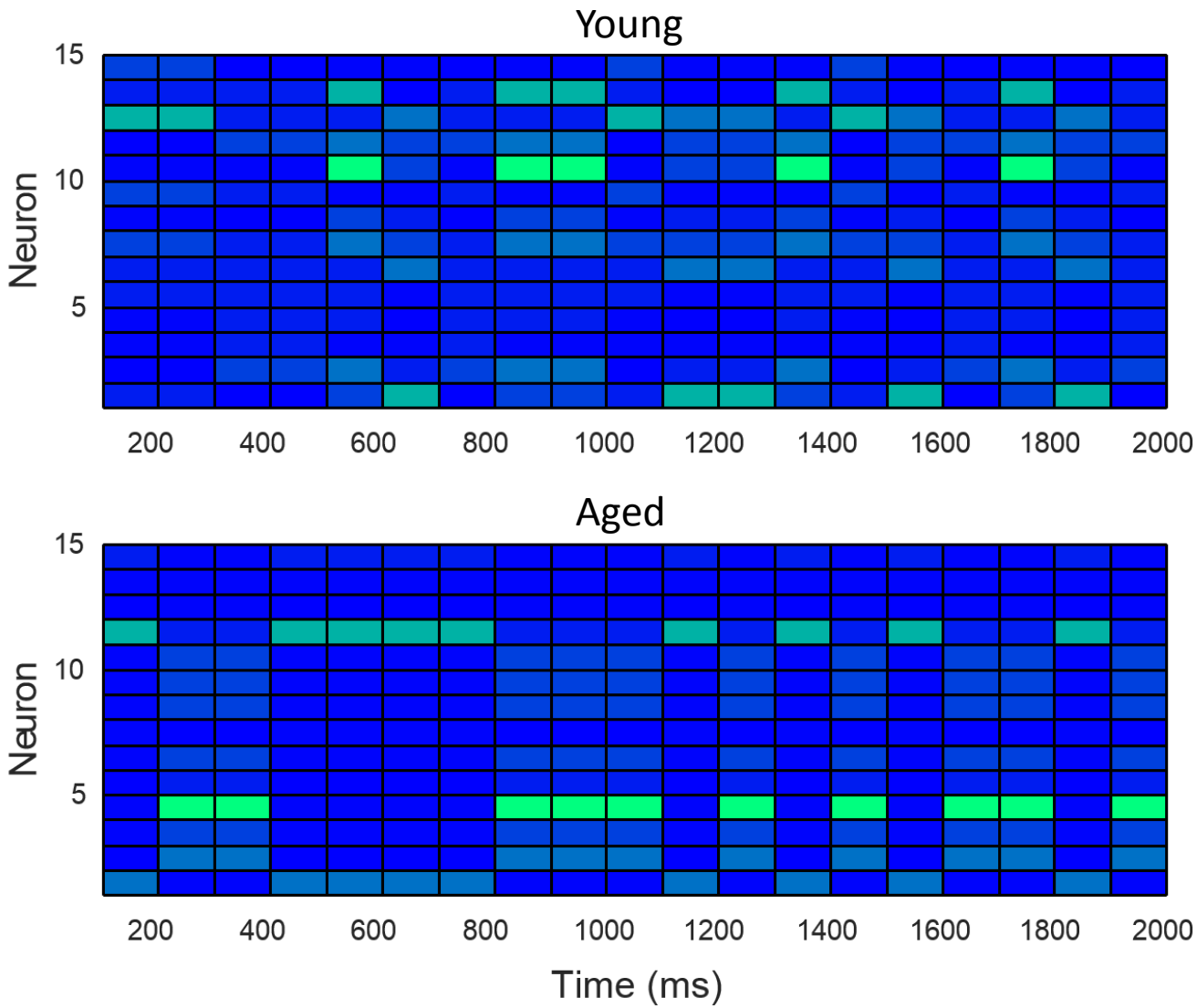

20 ms
A
Young
Aged
1.5
1
0.5
Hz
-600
-400
-200
0
200
400
600
ms
E
15
10
5
Hz
-600
-400
-200
0
200
400
600
ms

Variance

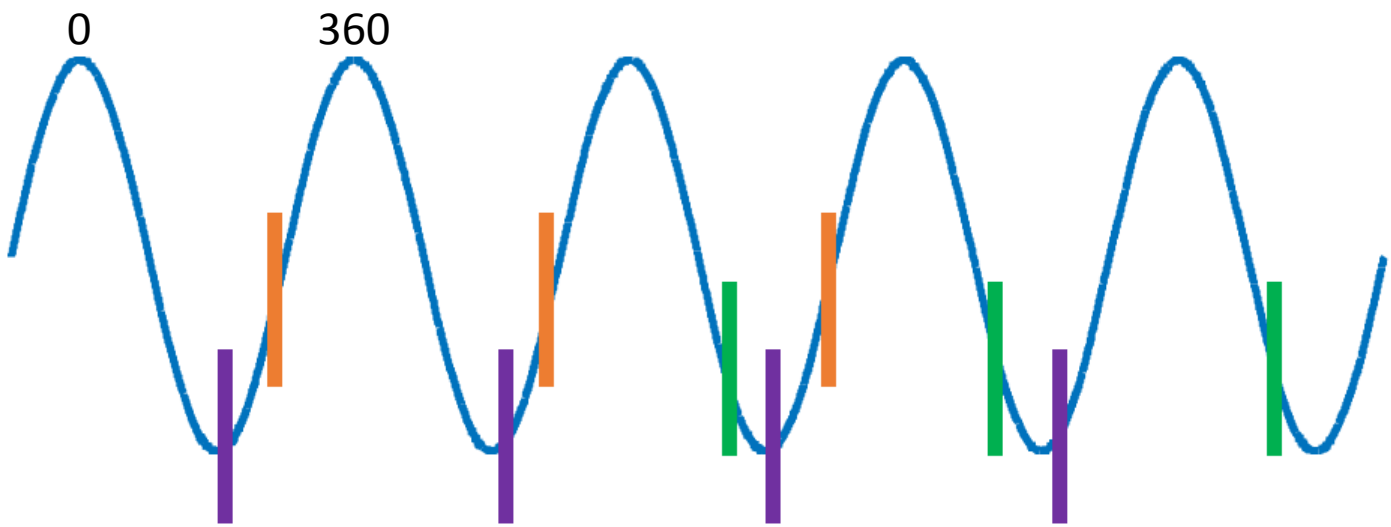
Mean

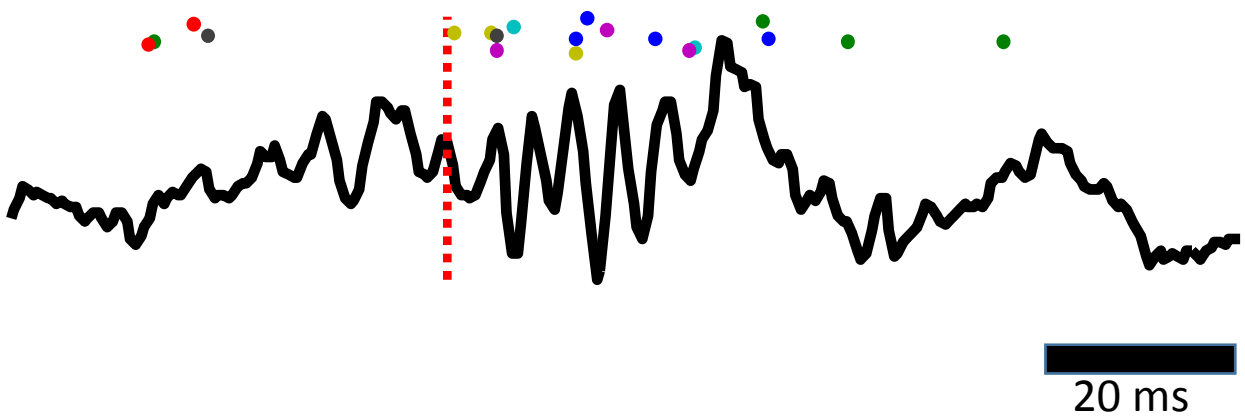


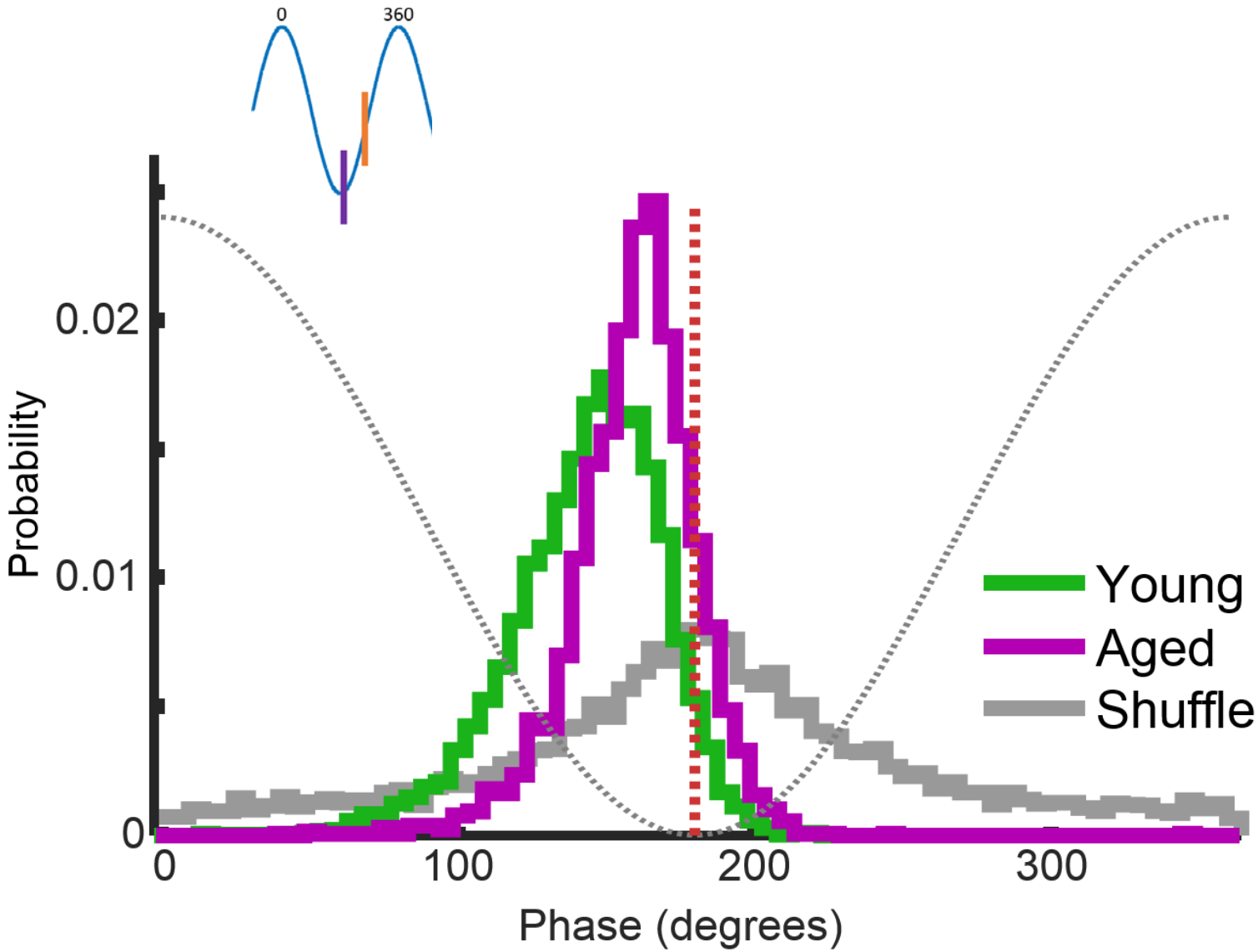



Young
Aged
Neuron
15
10
5
200
400
600
800
1000
1200
1400
1600
1800
2000
Time (ms)

Phase coding hypothesis

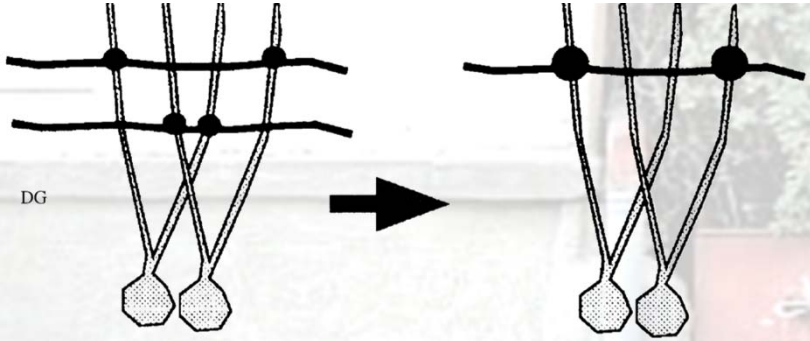






(a between-neuron measure)

Implications



- **Adaptive process.** Reduced variability may be a good thing. Larger synapses could compensate for synaptic pruning.
- **Possible Negative Consequence:** The aged brain has a more limited "vocabulary" available for encoding new memories.
- **Translation:** Approaches that increase variability in a targeted way may enhance encoding of new information.
  - TCDCS, TMS, drugs (NE).
- **Future: 1)**Investigate reactivation of previous experience, efficacy of reactivation in aged animals with preserved and impaired performance on memory tasks. **2)** Interventions that alter ripple density or amplitude. **3)** Dopamine

Acknowledgements



- Jean-Paul Wiegand
- Daniel Gray
- Tony Ye
- Many fantastic undergraduates

- Carol Barnes
- Lesley Schimanski

"To our relatives, the Rodents, with apologies."
– Valentino Braitenberg (1998)

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Future Directions

- Determine if reactivation (a correlate of consolidation) is this impaired or actually increased in aged animals that…
  - Do well on memory tasks.
- Explore techniques, such as TDCS or drug therapies that could potentially increase ripple density.