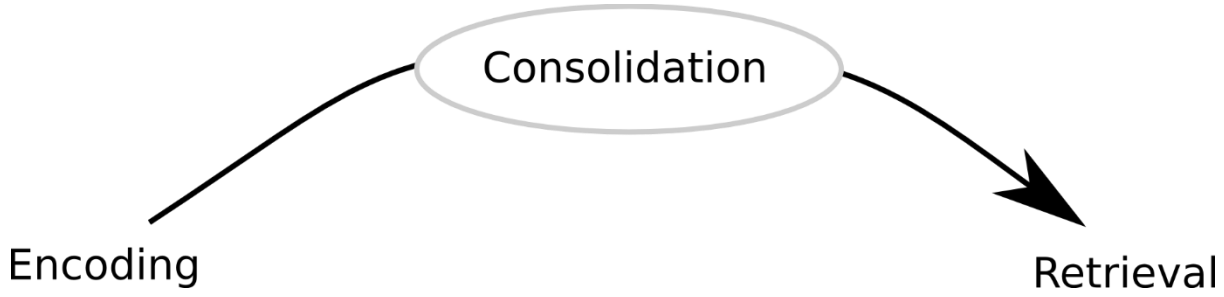
MRC | Brain Network Dynamics Unit

UNIVERSITY OF OXFORD

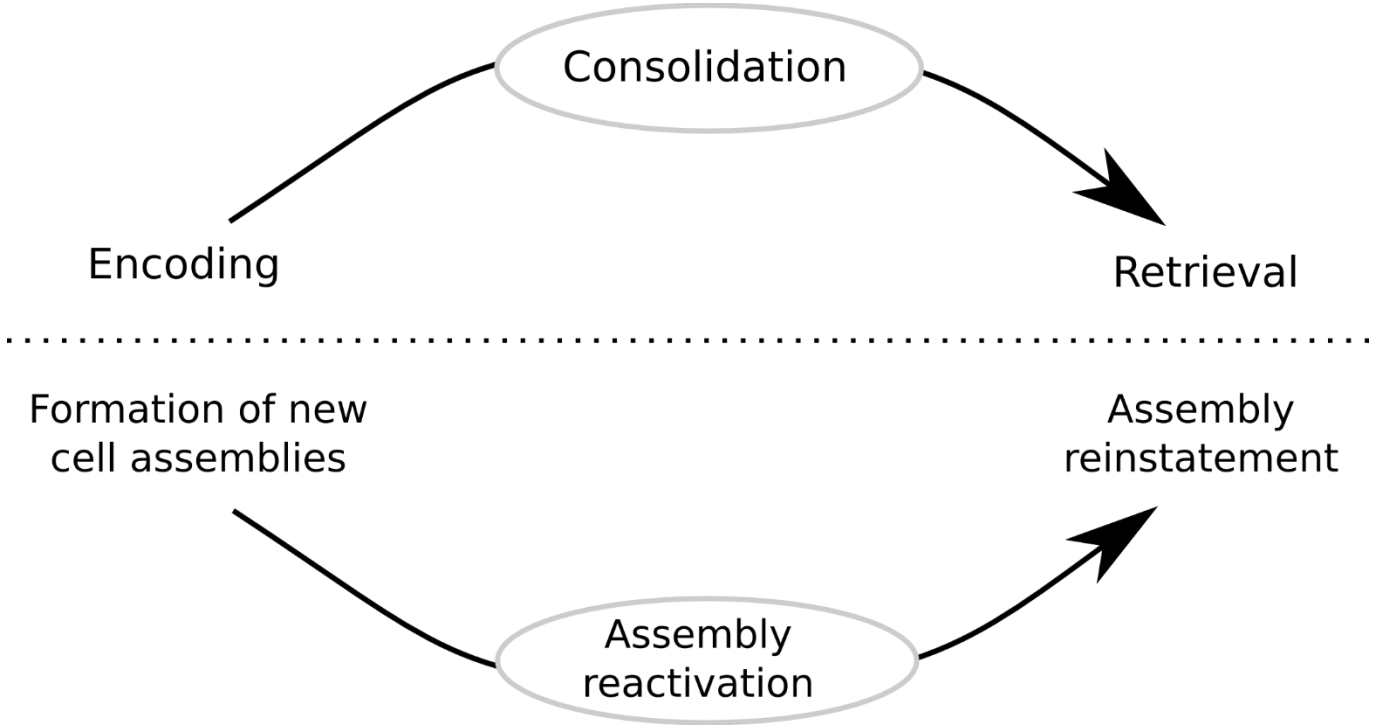
Hippocampal reactivation stabilizes recently formed cell assembly patterns

Gido van de Ven

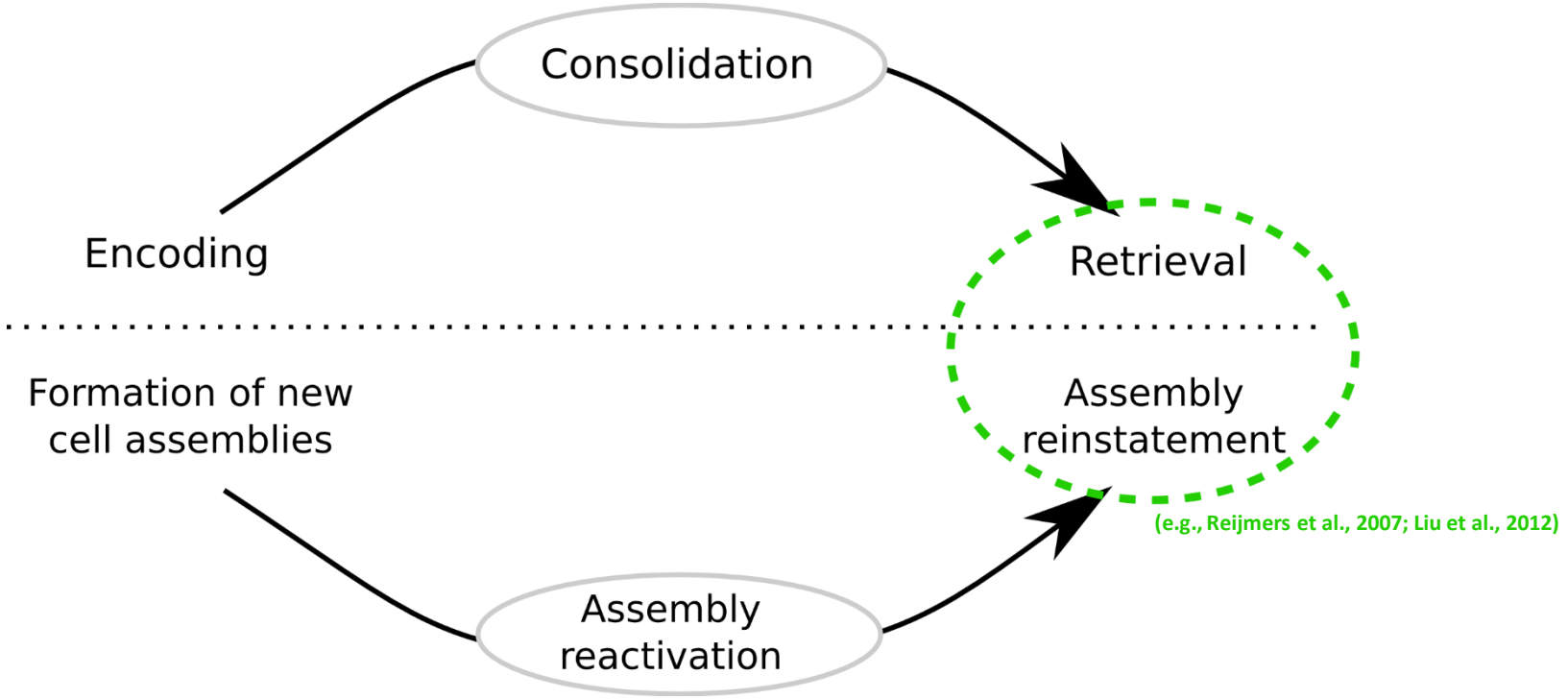
Memory-consolidation



Memory-consolidation:
cell assembly / reactivation hypothesis

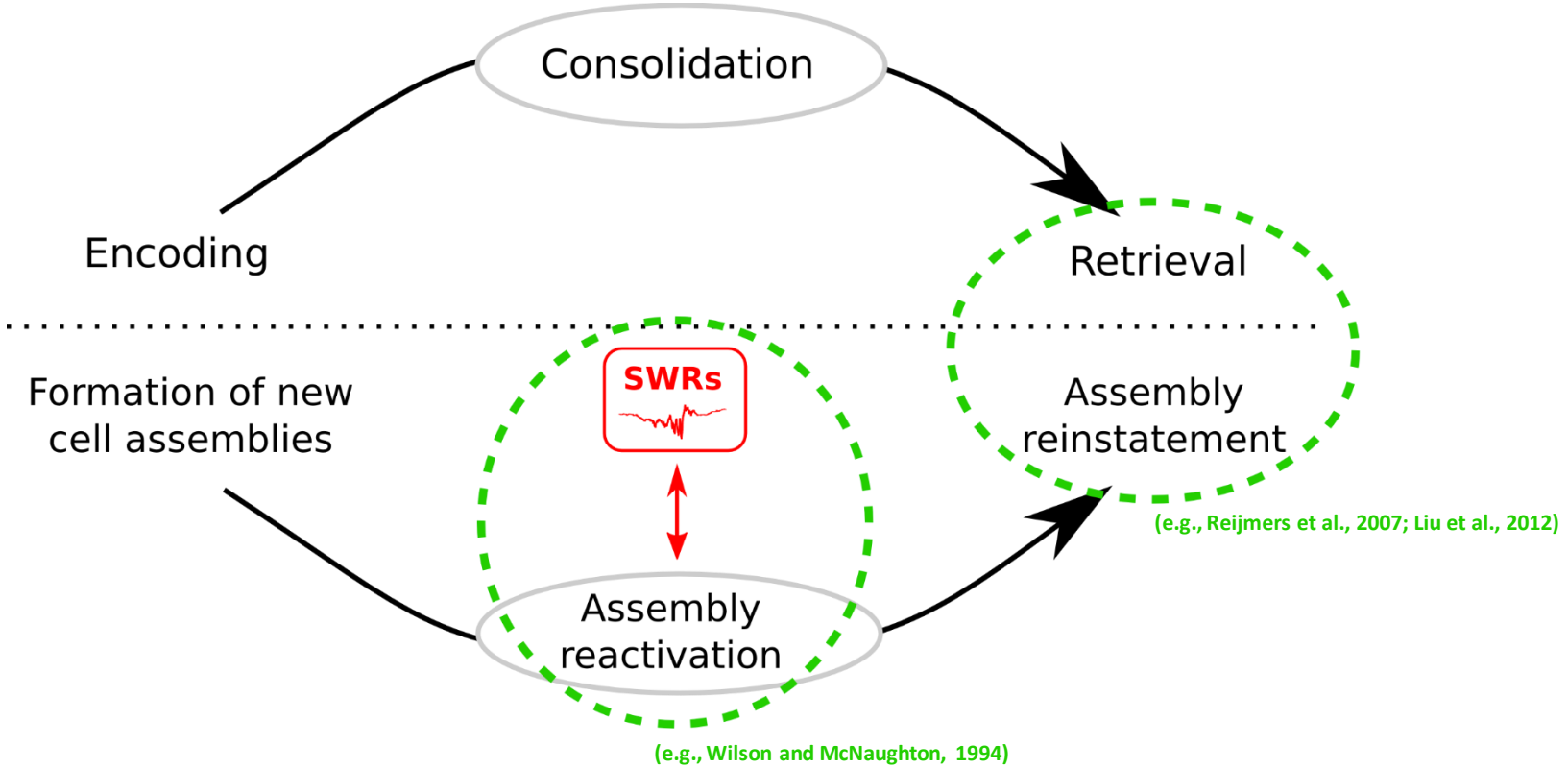


Memory-consolidation:
cell assembly / reactivation hypothesis

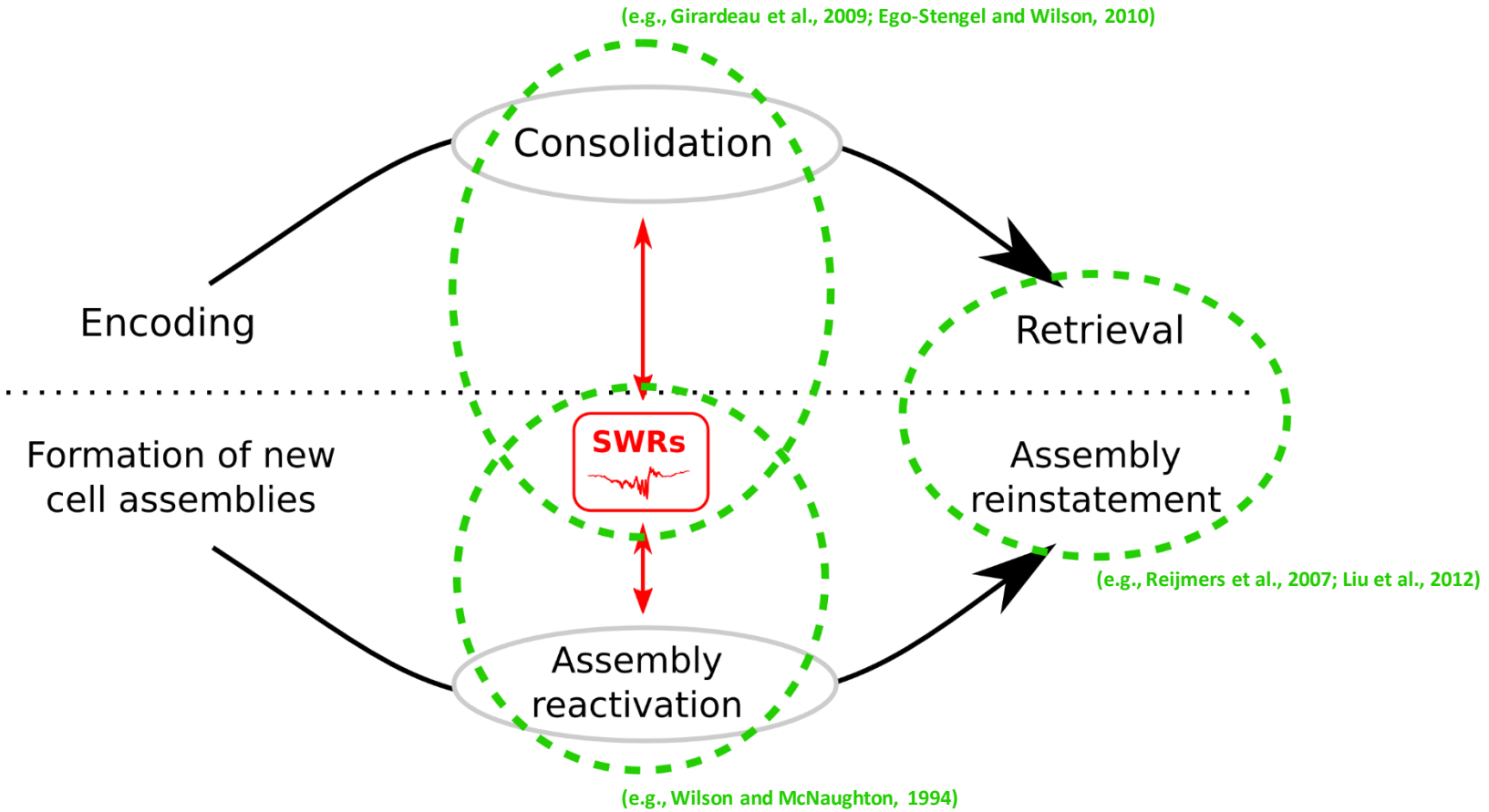


(e.g., Reijmers et al., 2007; Liu et al., 2012)

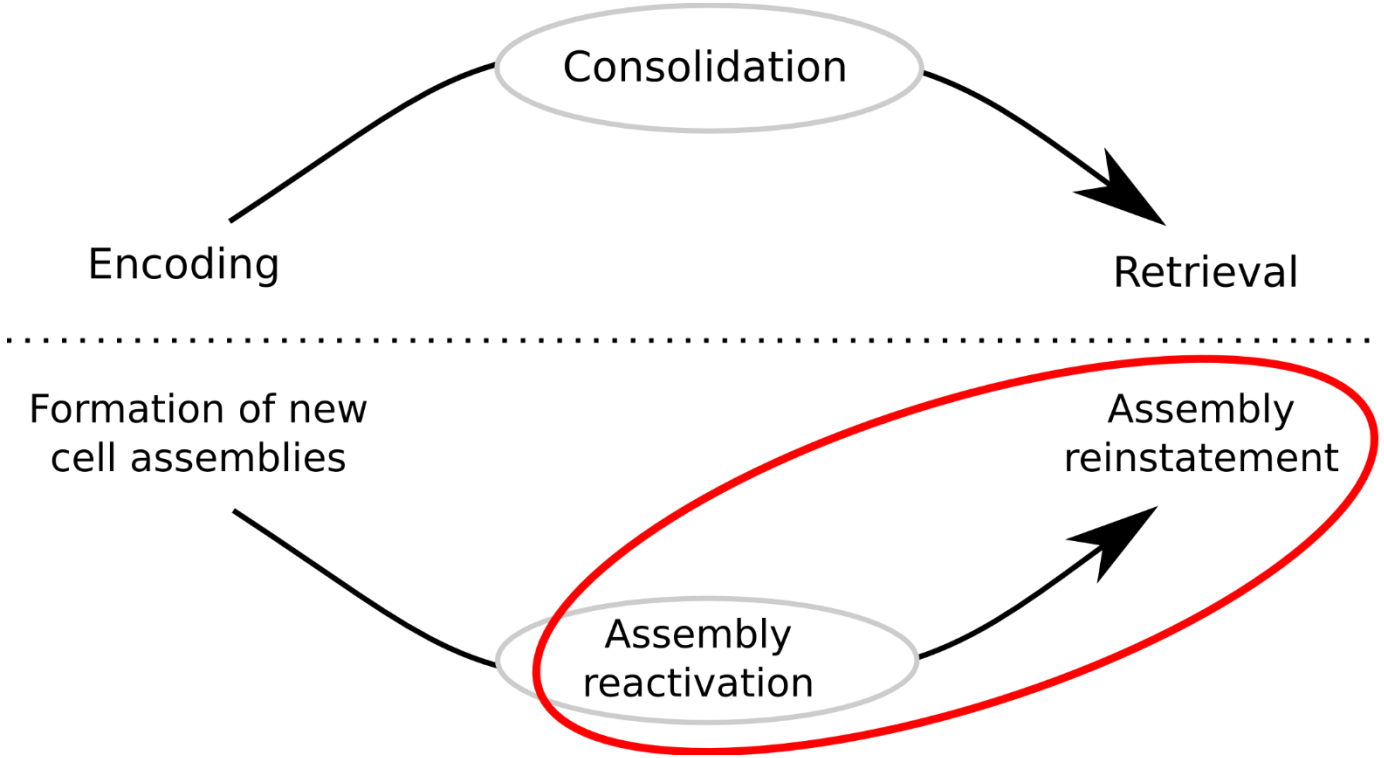
Memory-consolidation:
cell assembly / reactivation hypothesis



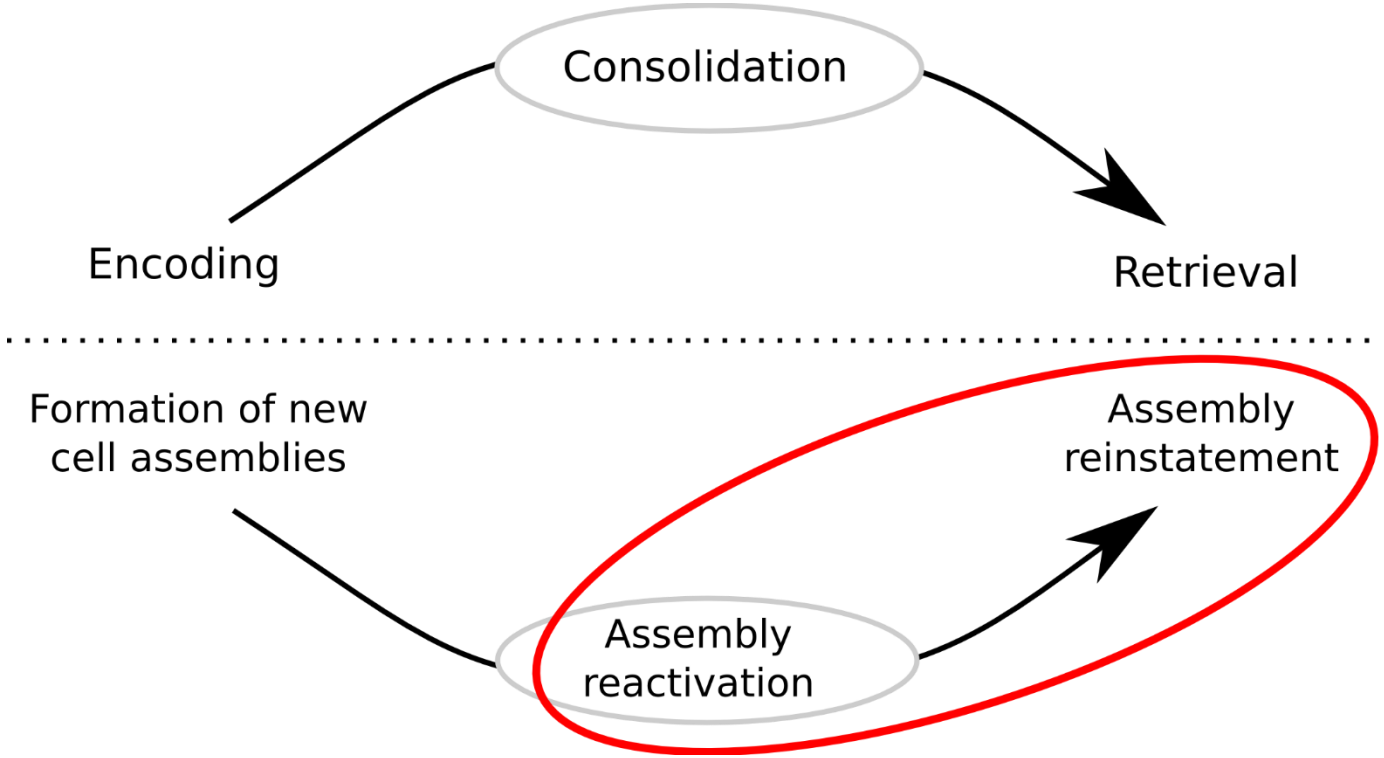
Memory-consolidation:
cell assembly / reactivation hypothesis



Memory-consolidation:
cell assembly / reactivation hypothesis



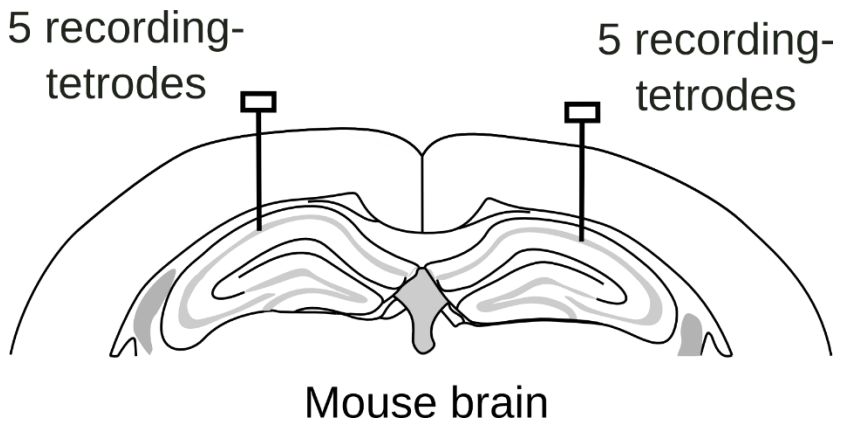
Memory-consolidation:
cell assembly / reactivation hypothesis

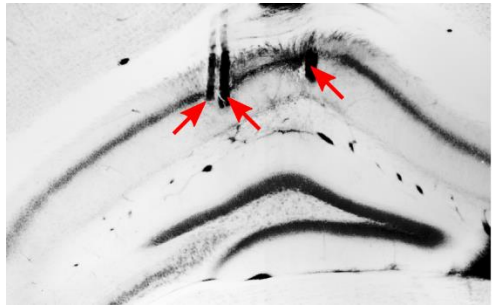


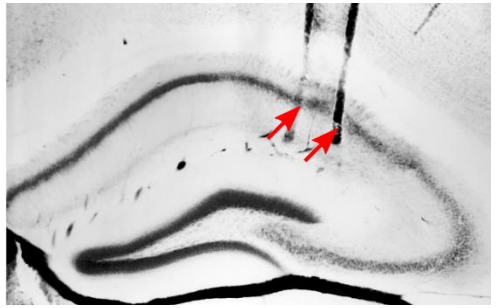
2 challenges: → Identification & tracking of "memory-representing" cell assemblies
→ Selective disruption of reactivation

Identification of “cell assemblies”

= challenge 1

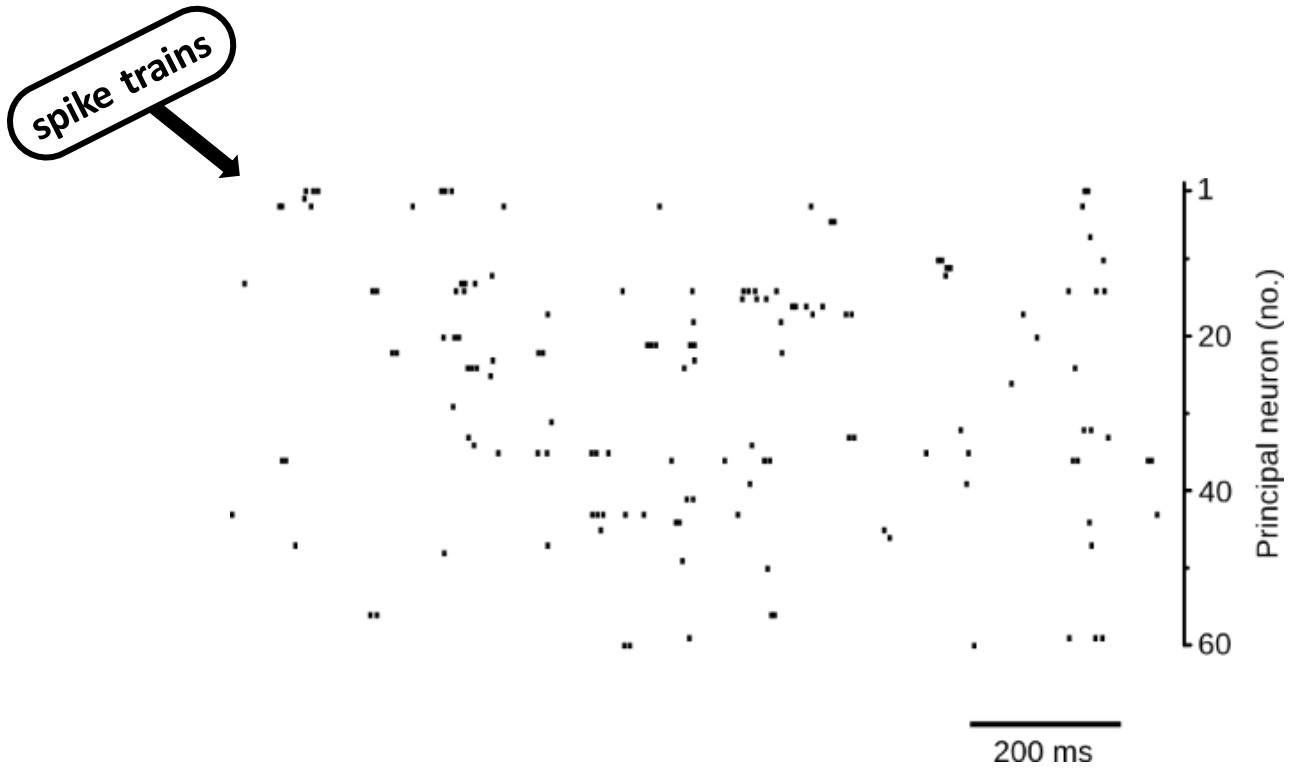


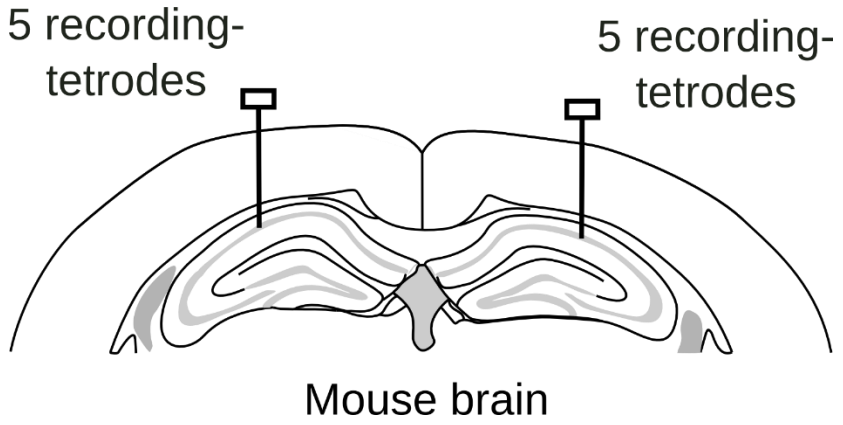


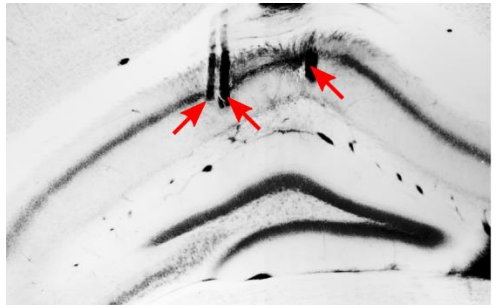


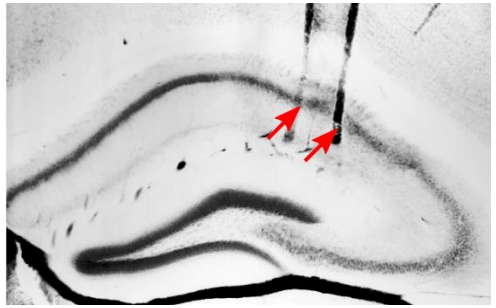
Identification of “cell assemblies”

= challenge 1

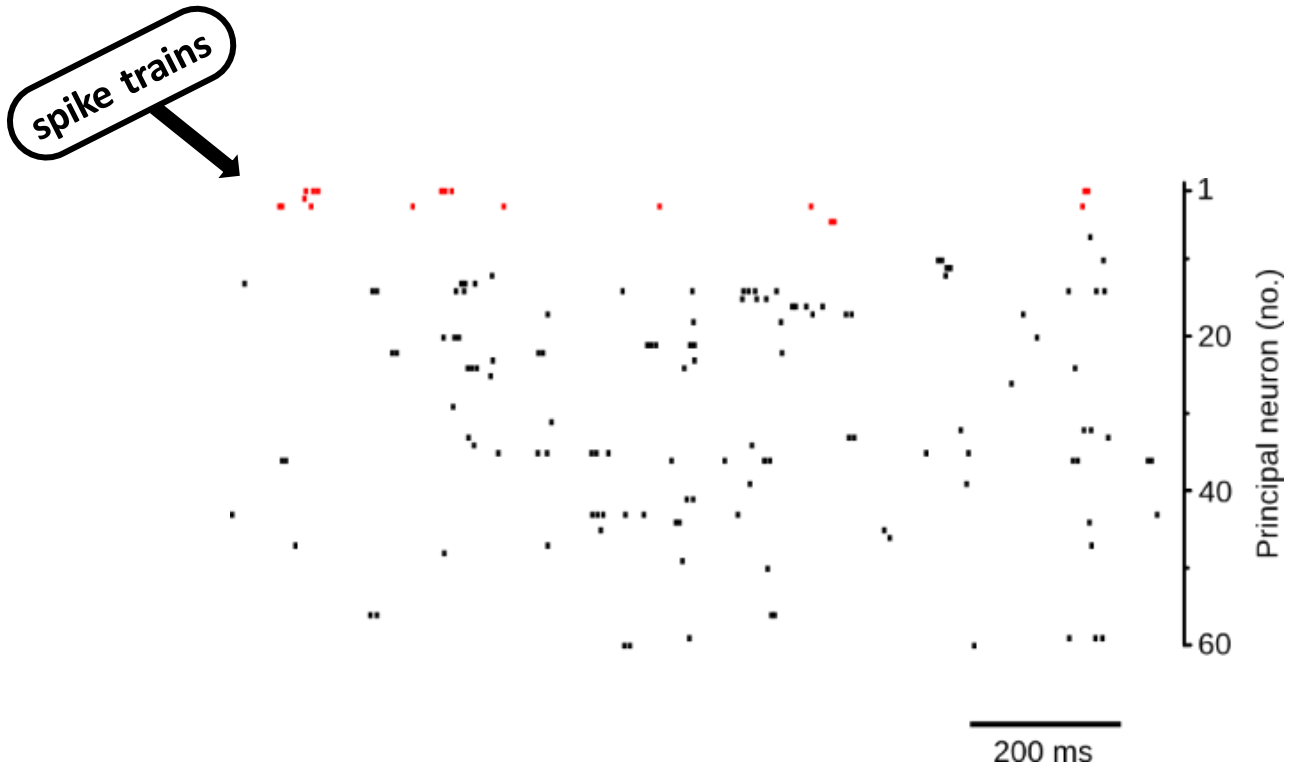




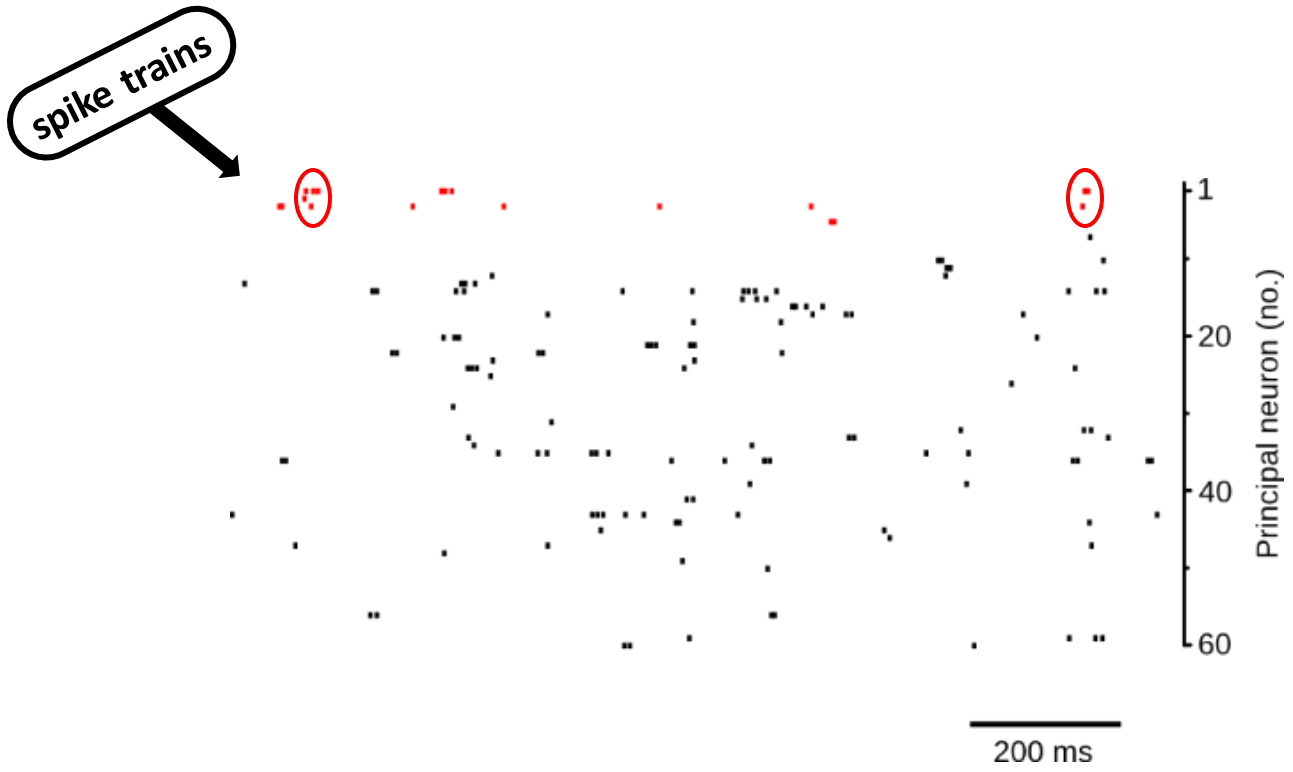




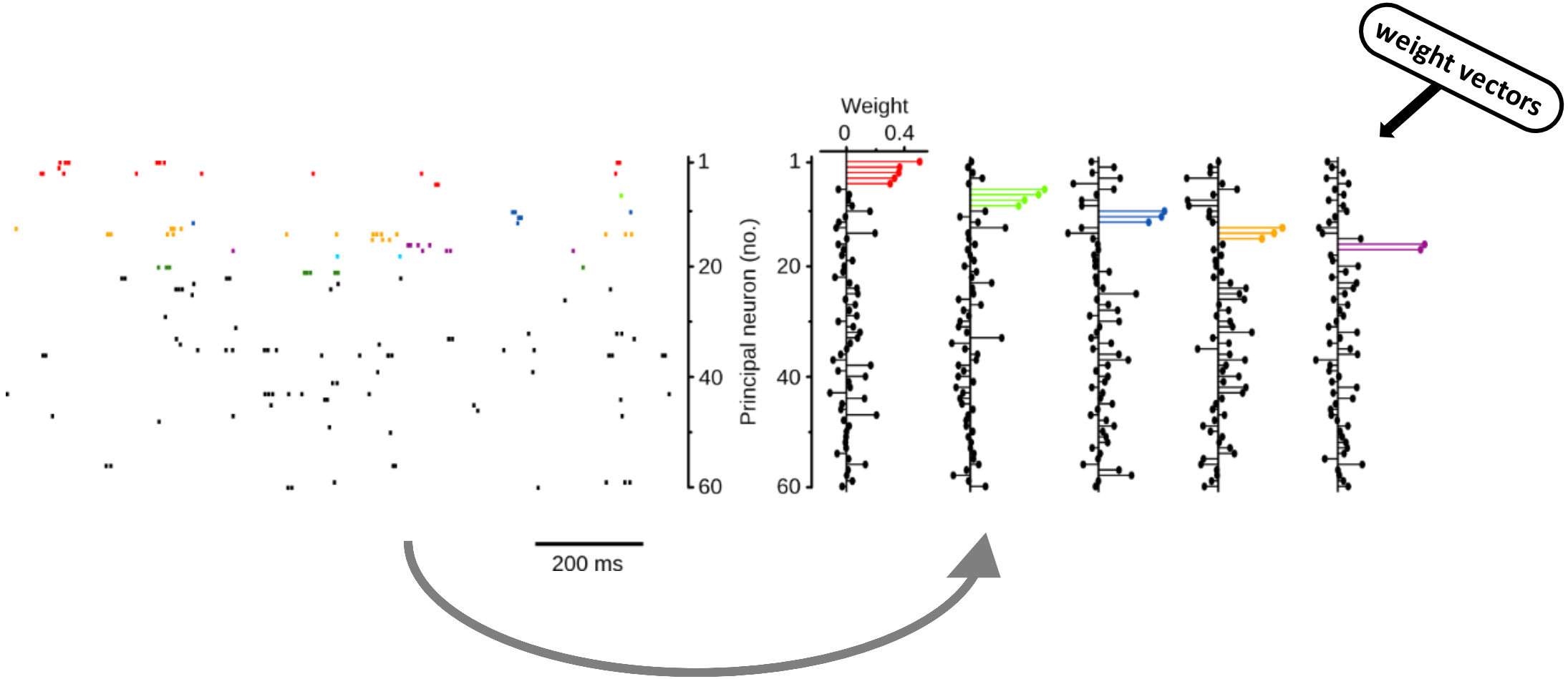
Identification of “cell assemblies”



Identification of “cell assemblies”

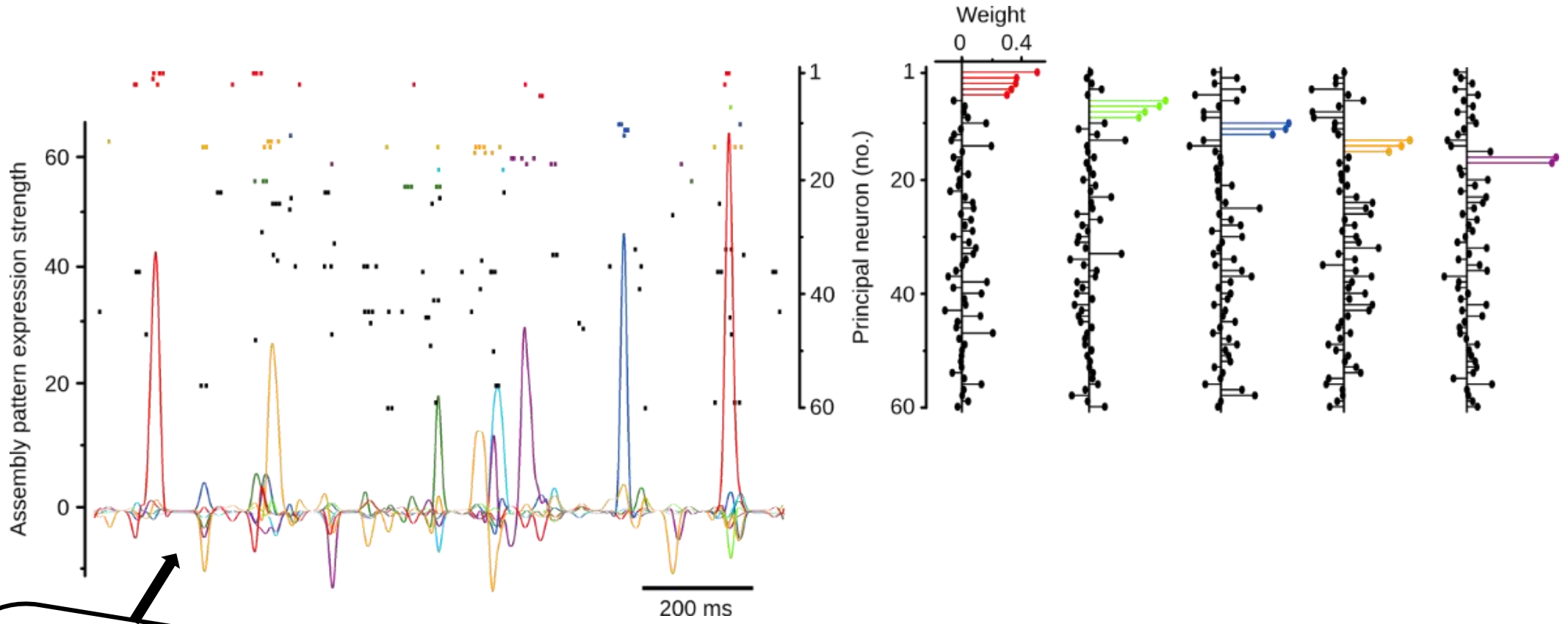


Identification of “cell assemblies”



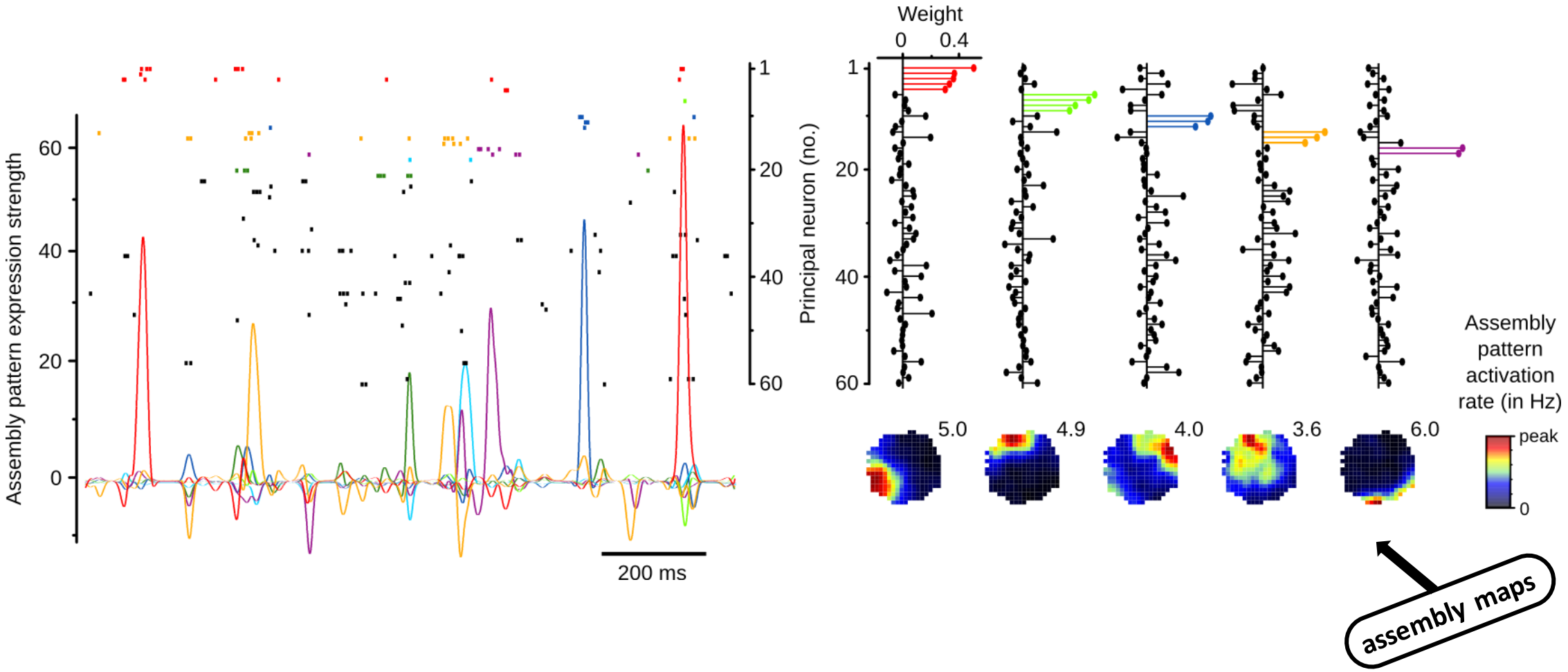
Assembly-detection method based on PCA and ICA

Identification of “cell assemblies”



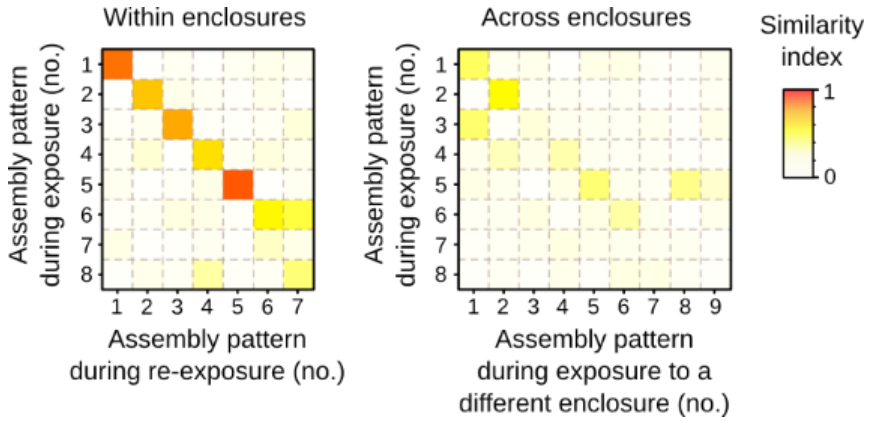
assembly pattern expression-strength tracked over time

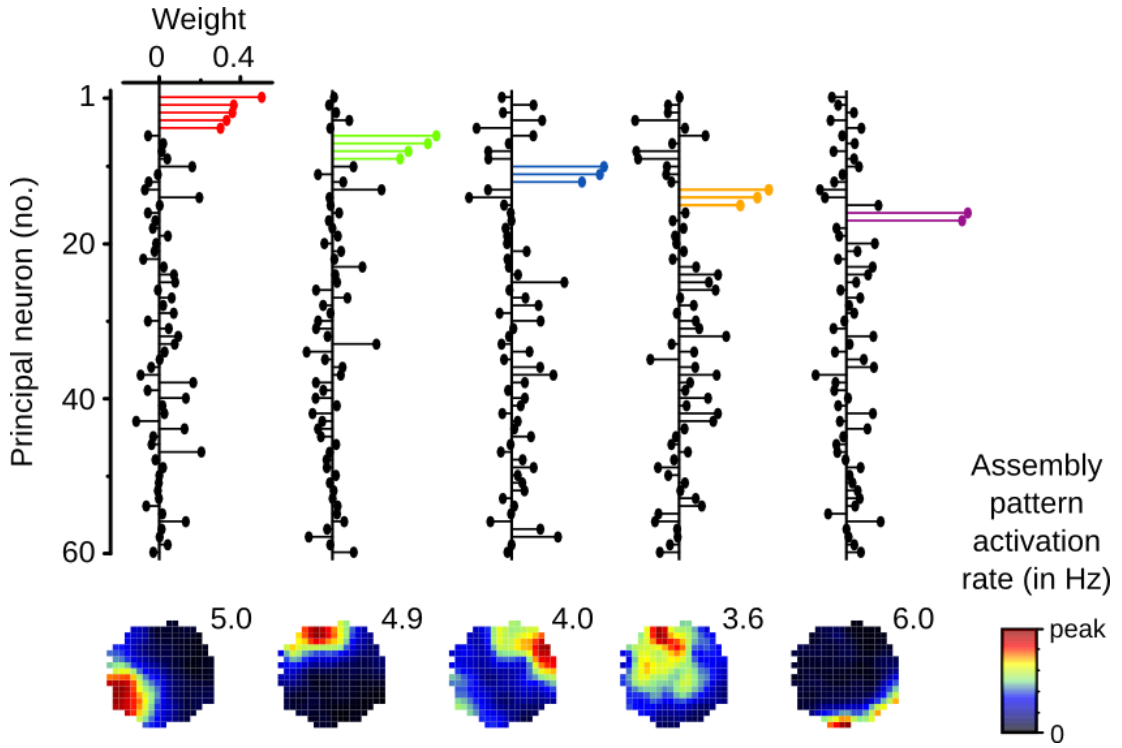
Identification of “cell assemblies”



Identification of “cell assemblies”

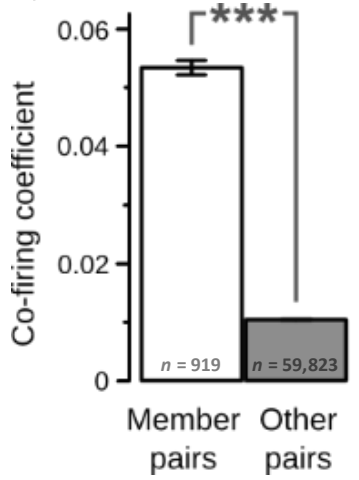
assembly patterns are environment-specific



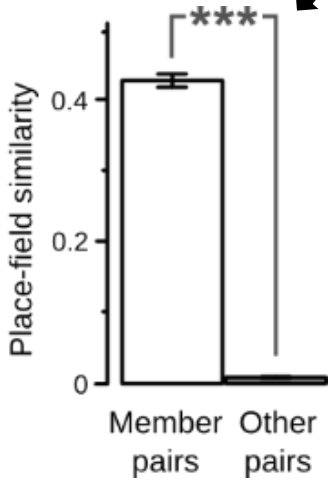


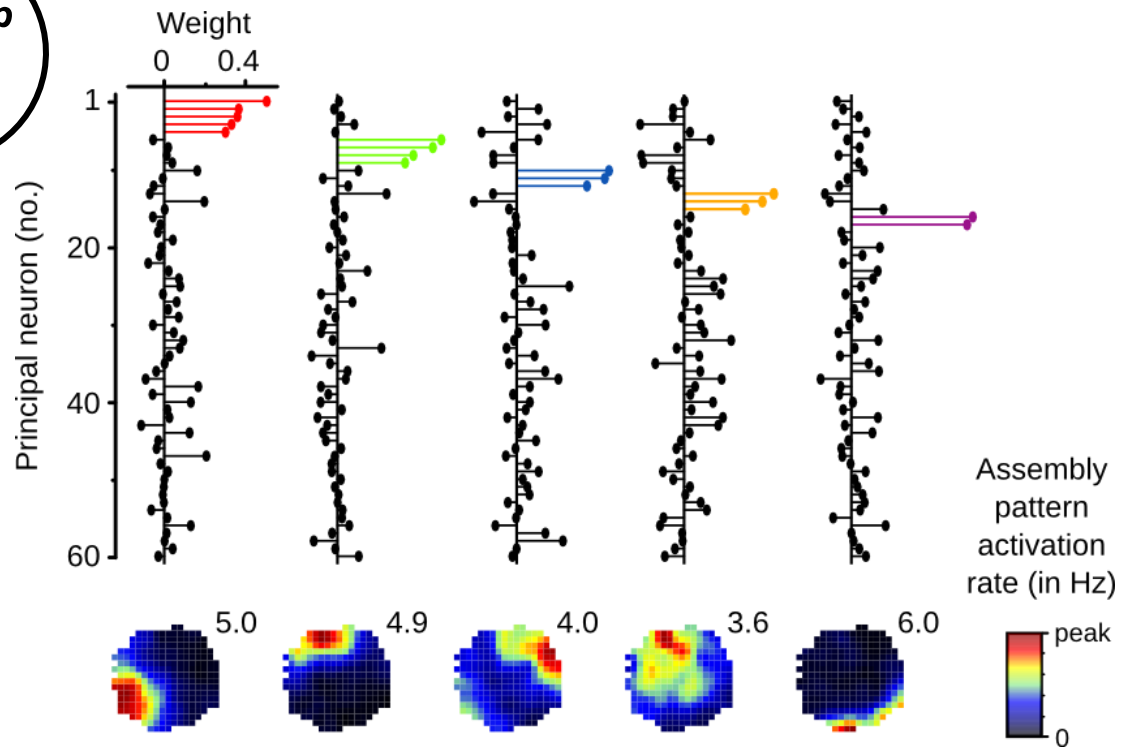
Identification of “cell assemblies”

assembly patterns group together co-active neurons

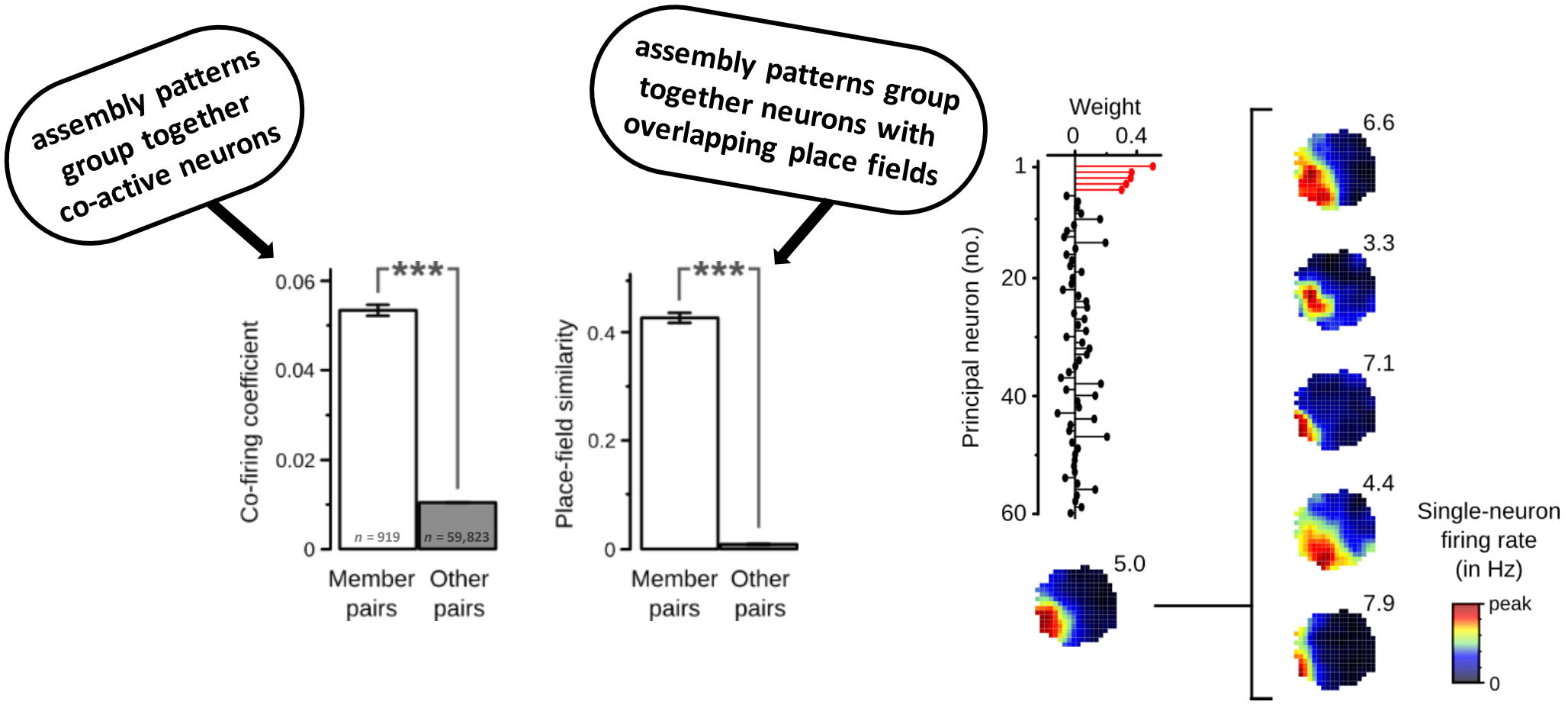


assembly patterns group together neurons with overlapping place fields





Identification of “cell assemblies”



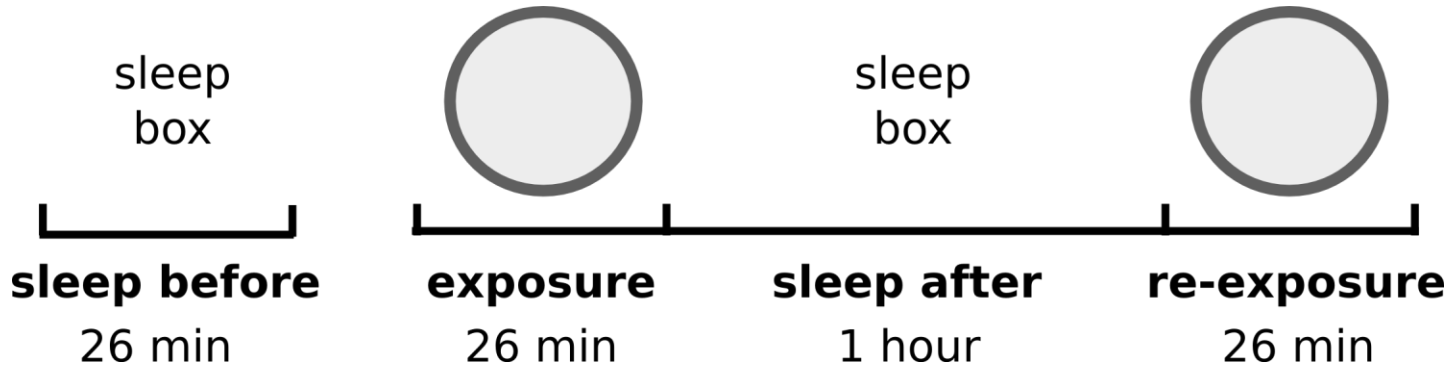
Identification of “cell assemblies” - summary

Based on short-time scale interactions (25 ms) in tetrode recordings of hippocampal principal neurons, an unsupervised statistical framework based on PCA and ICA ***detects*** and ***tracks*** cell assembly patterns that:

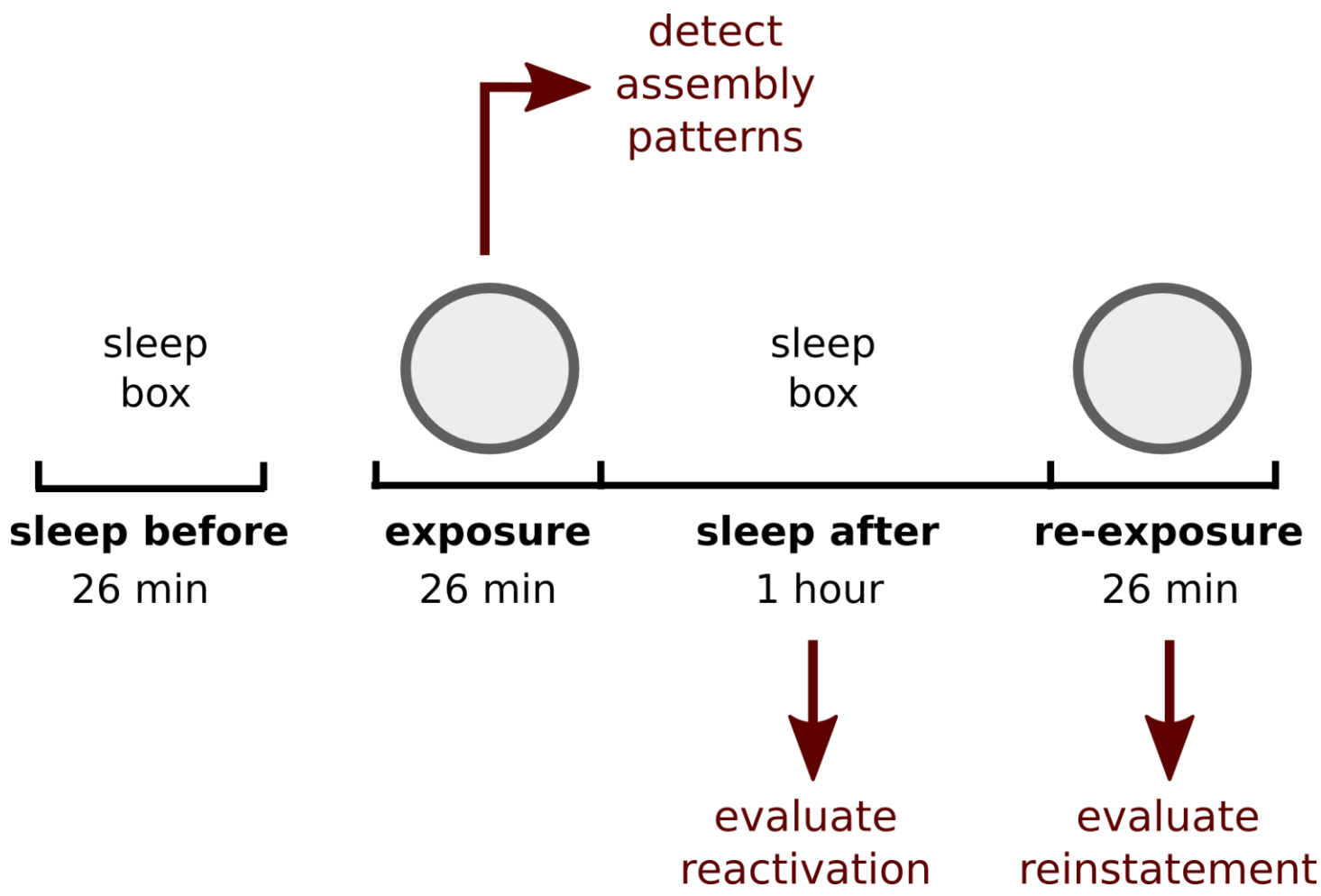
- are spatially selective;
- are environment-specific;
- bind together co-active neurons; and
- bind together neurons with overlapping spatial tuning.

→ **challenge 1**: Identification & tracking of “memory-representing” cell assemblies

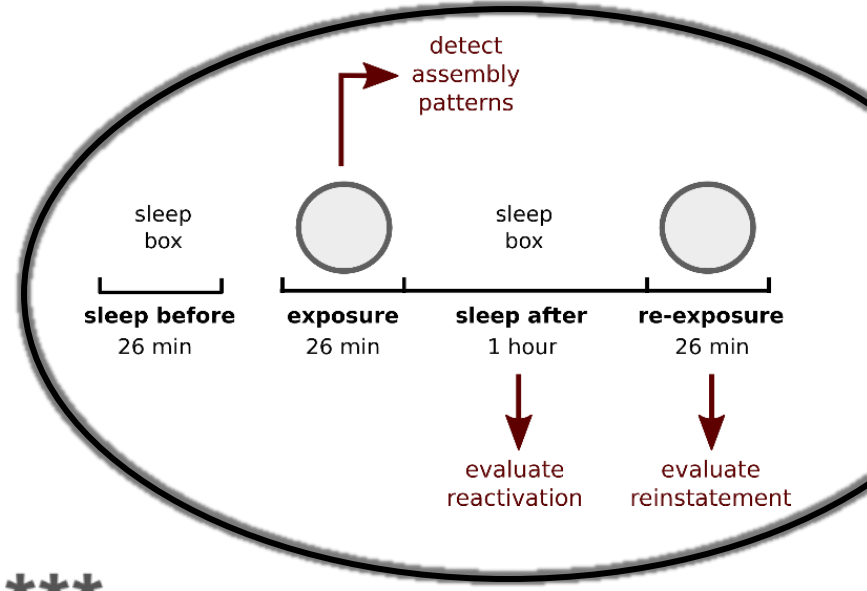
Experimental protocol

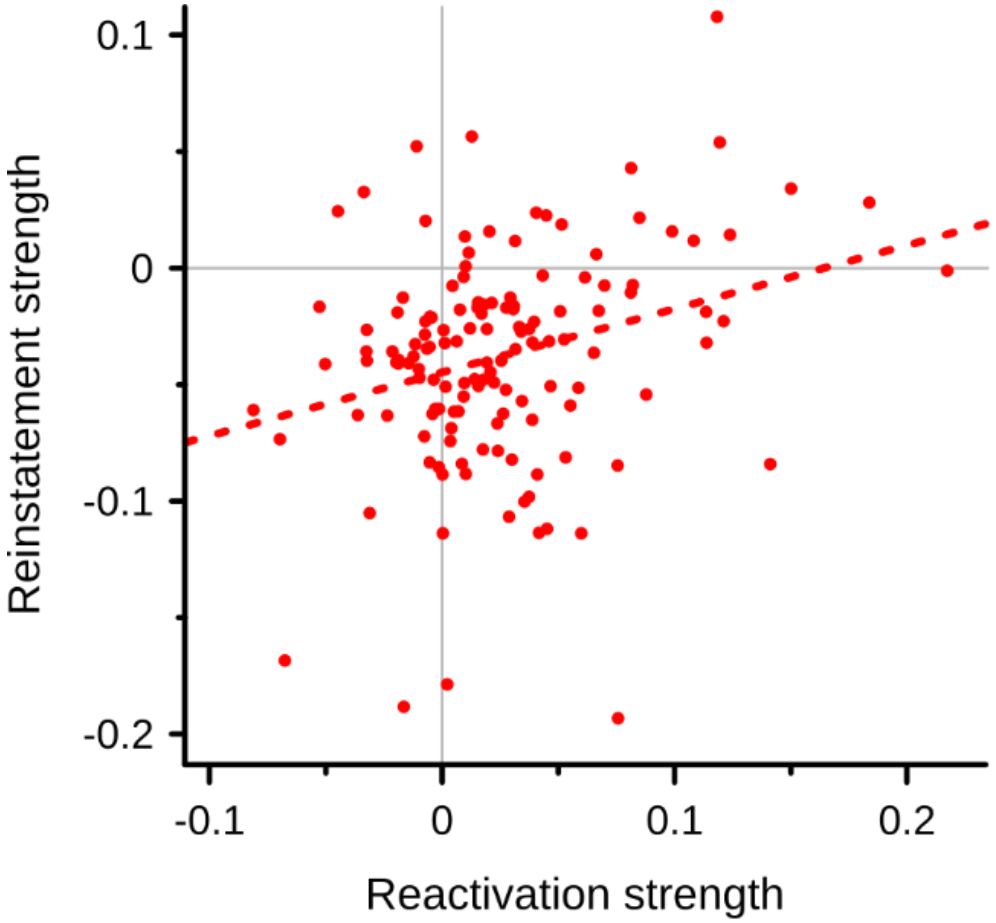


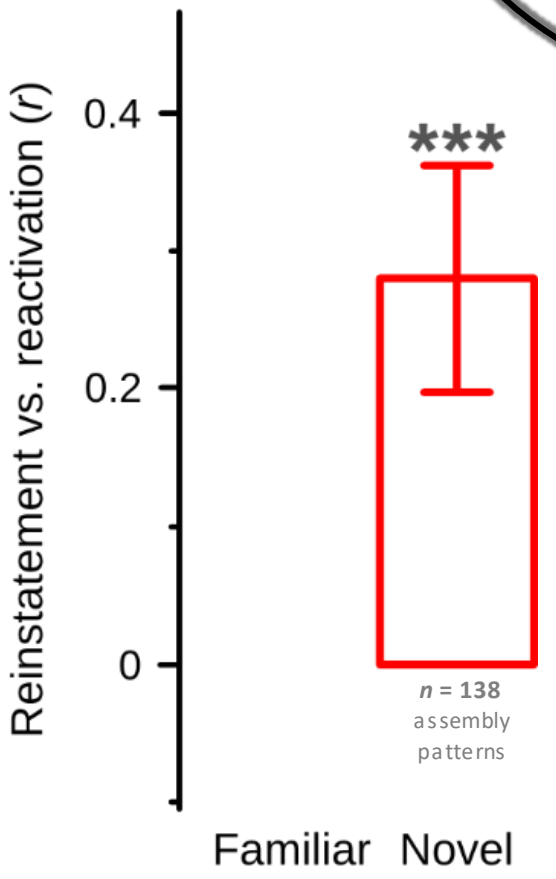
Experimental protocol - (*correlation*)



An assembly pattern's reactivation predicts it subsequent reinstatement

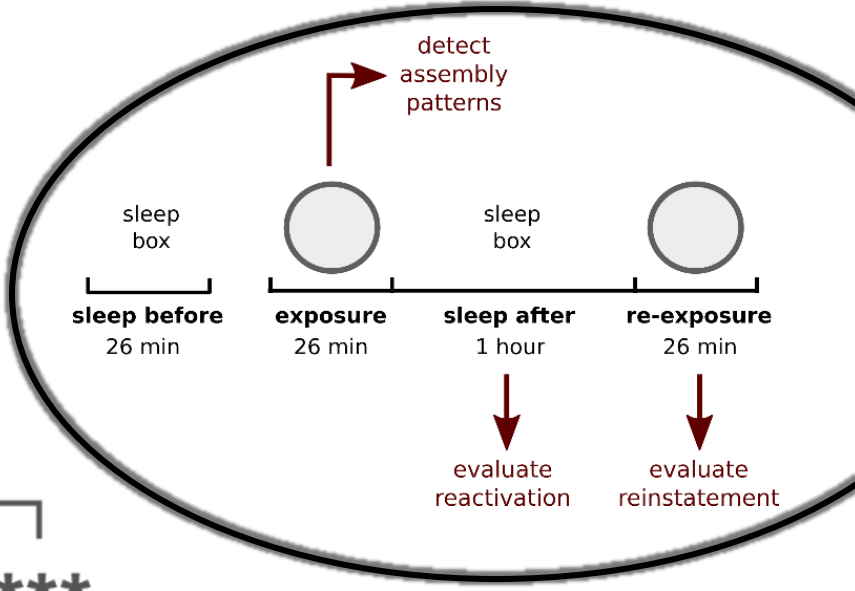


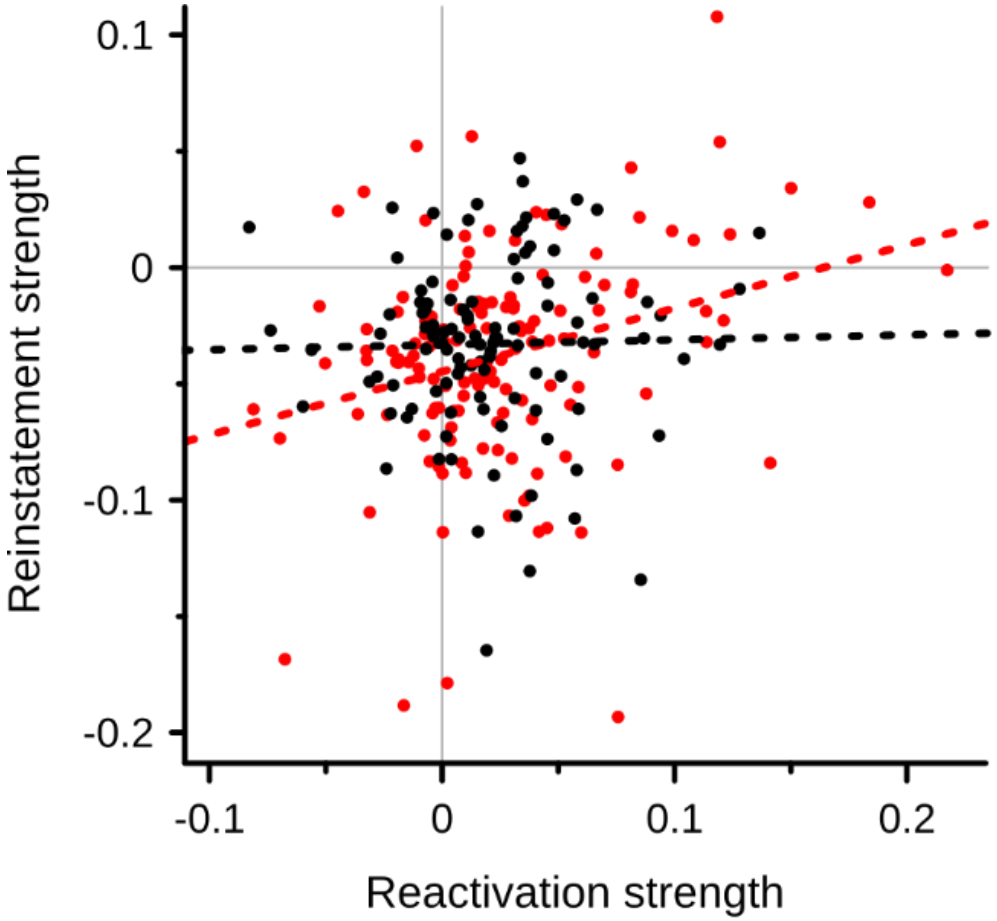


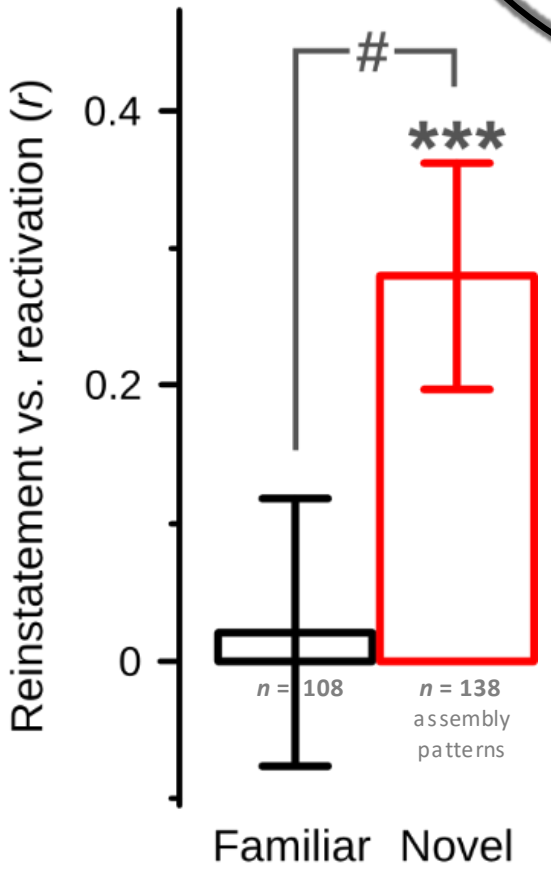


(based on 43 recording-blocks from 8 mice)

An assembly pattern's reactivation predicts it subsequent reinstatement







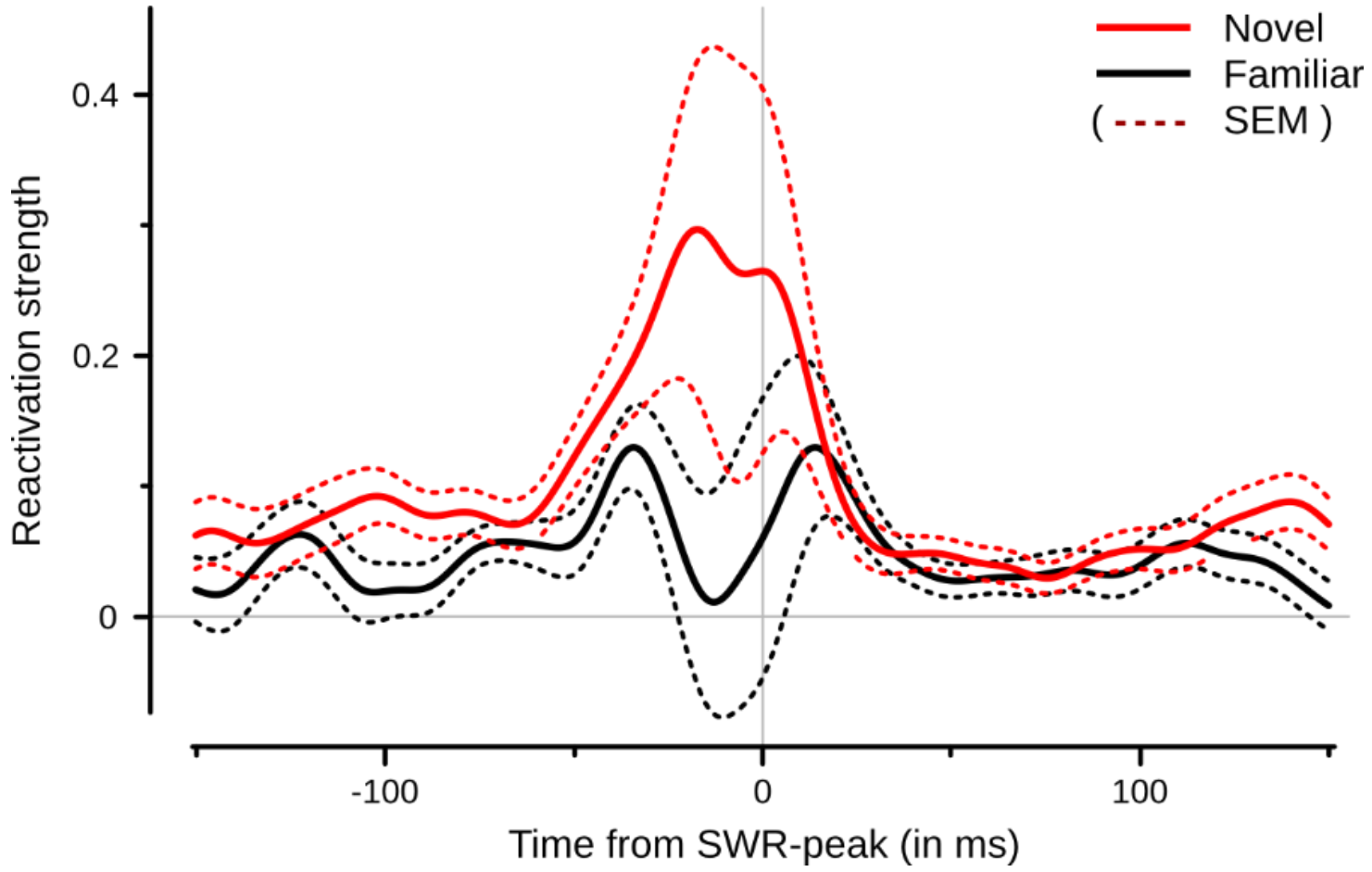
(based on 43 recording-blocks from 8 mice)

Selective disruption of reactivation?

= **challenge 2**

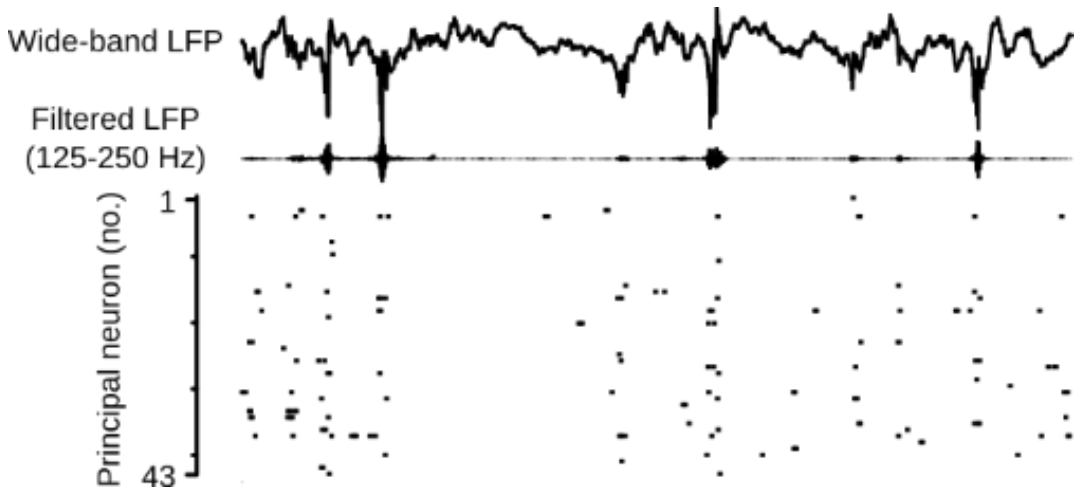
Selective disruption of reactivation?

= challenge 2

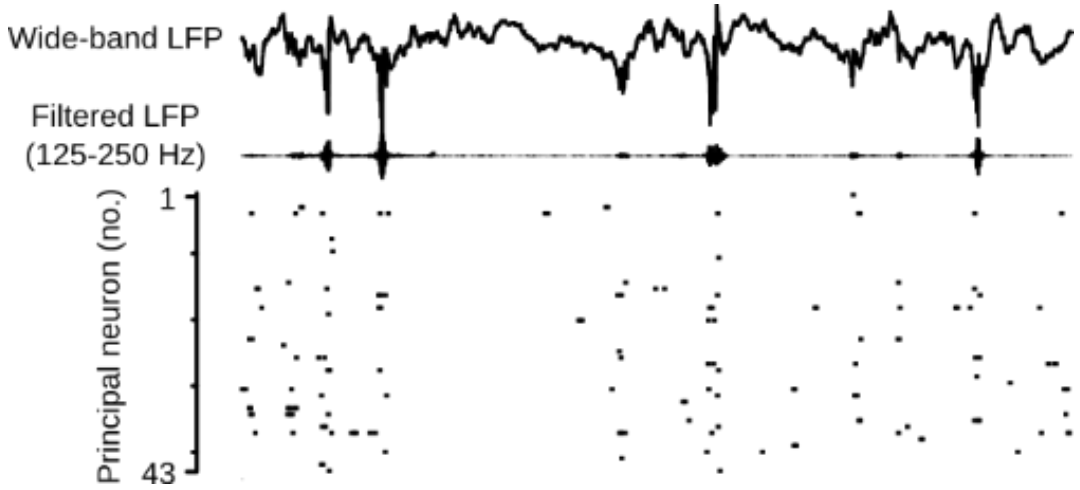


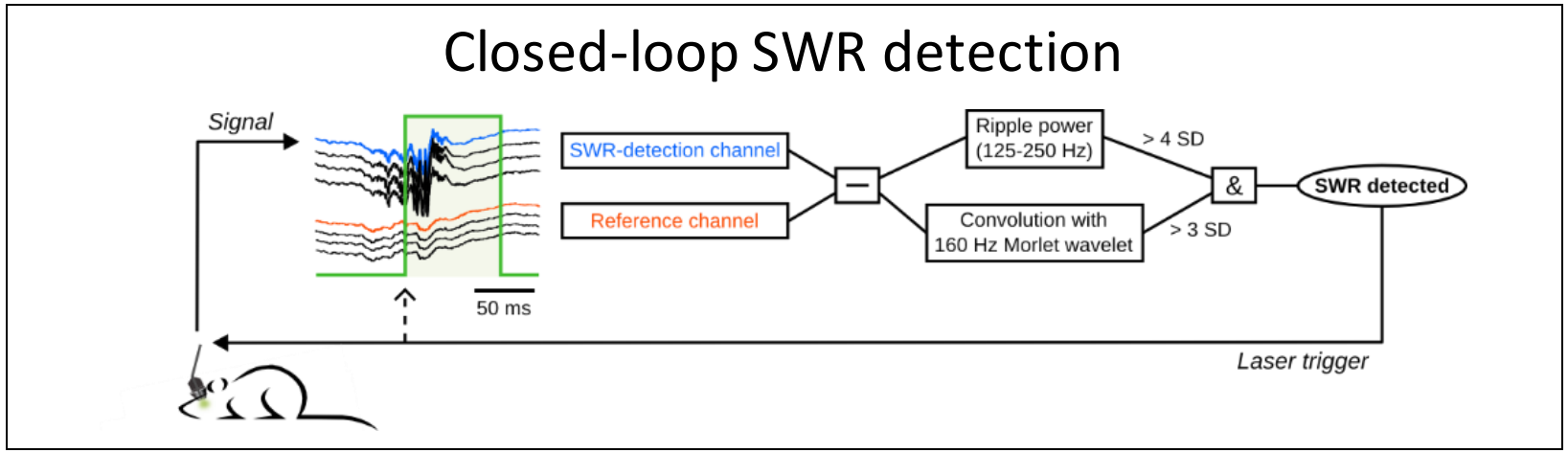
Novel: *n* = 139 assembly-patterns
Familiar: *n* = 108 assembly-patterns
(based on 43 recording-blocks from 8 mice)

Selective disruption of reactivation: *optogenetic SWR silencing*

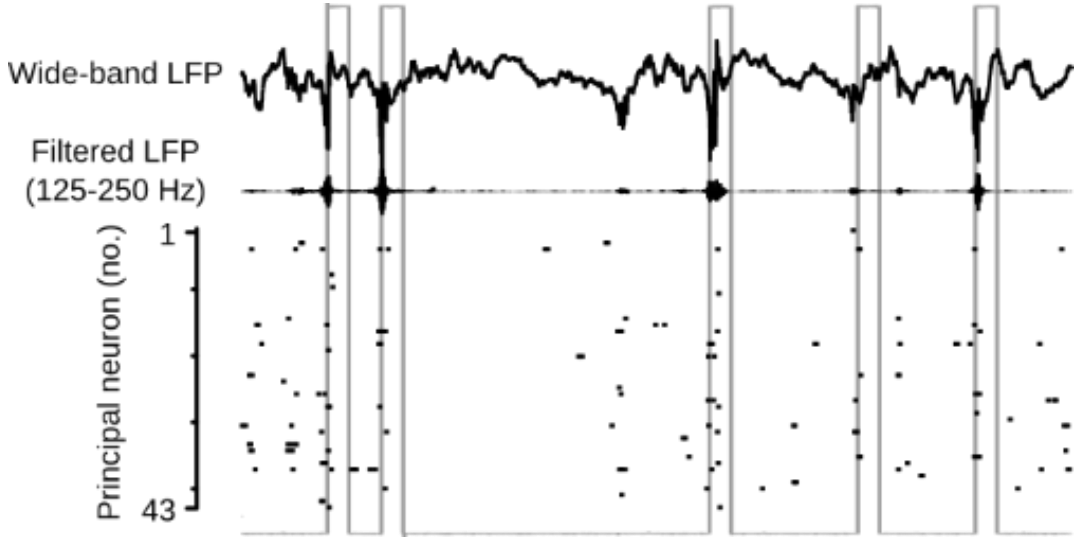


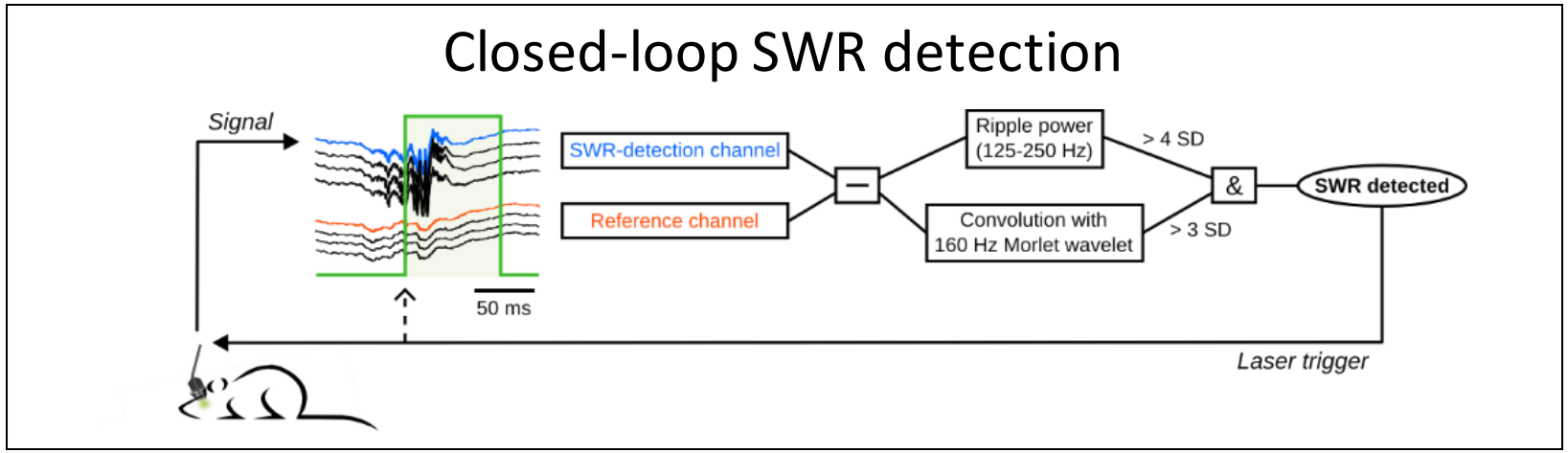
Selective disruption of reactivation: *optogenetic SWR silencing*



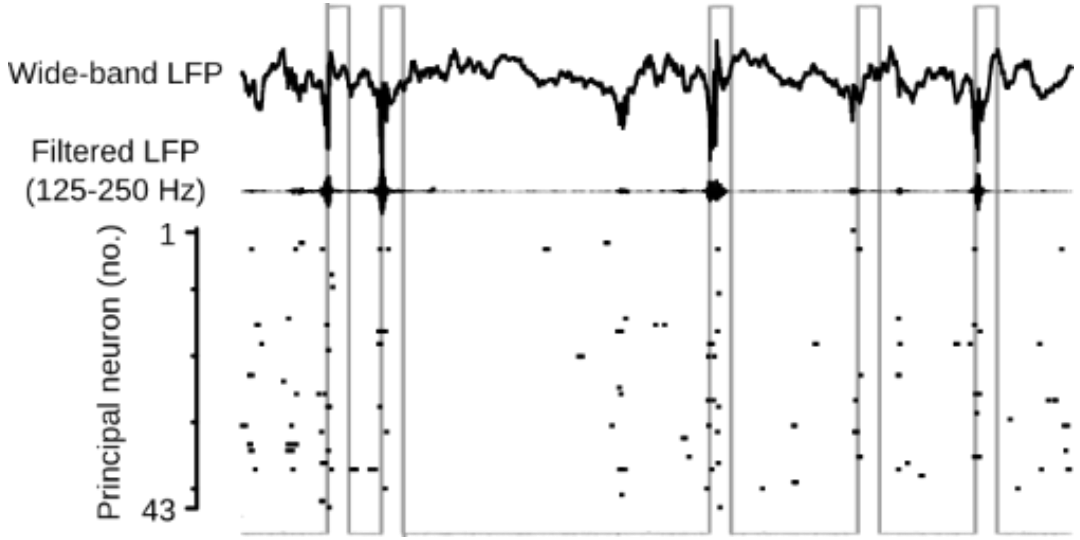


Selective disruption of reactivation: *optogenetic SWR silencing*

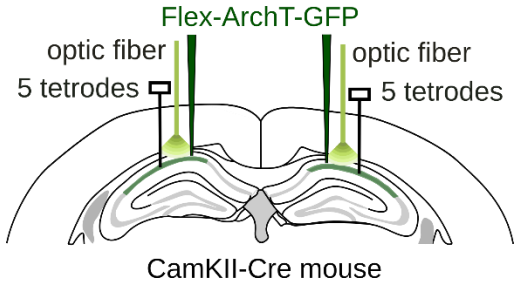


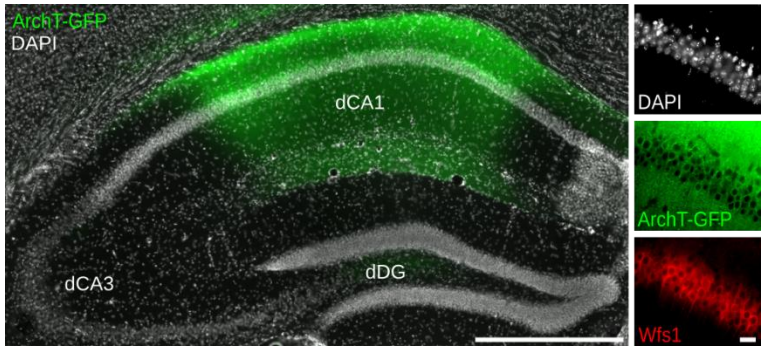


Selective disruption of reactivation: *optogenetic SWR silencing*

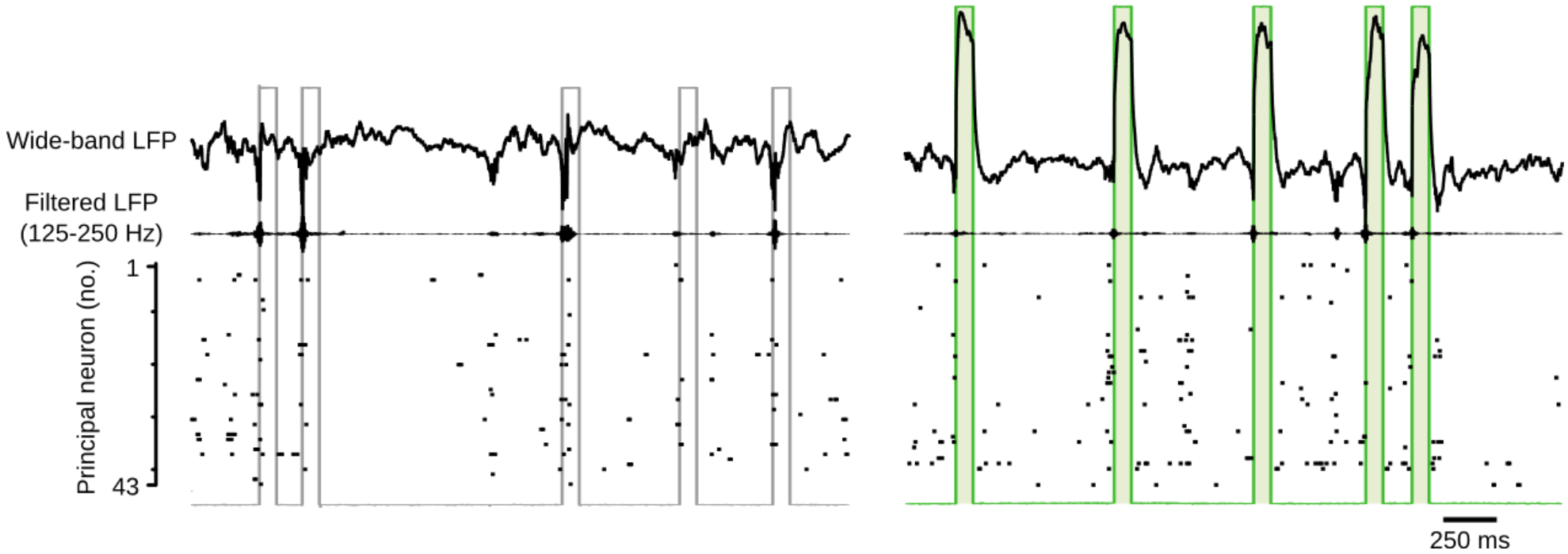


Optogenetic silencing of CamKII-positive cells using ArchT

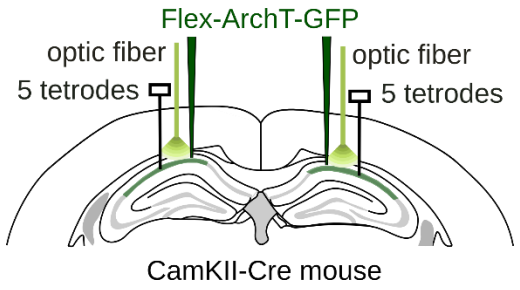


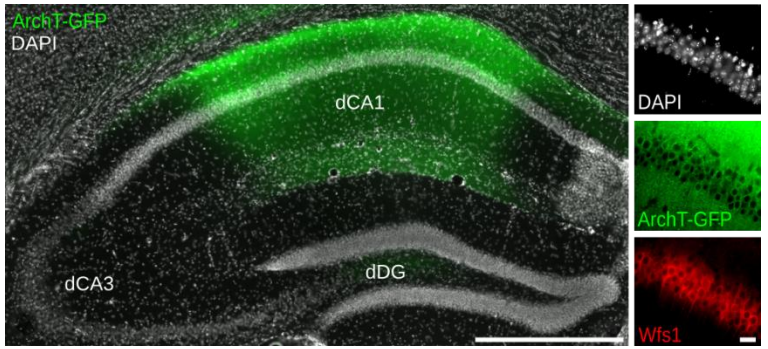


Selective disruption of reactivation: *optogenetic SWR silencing*

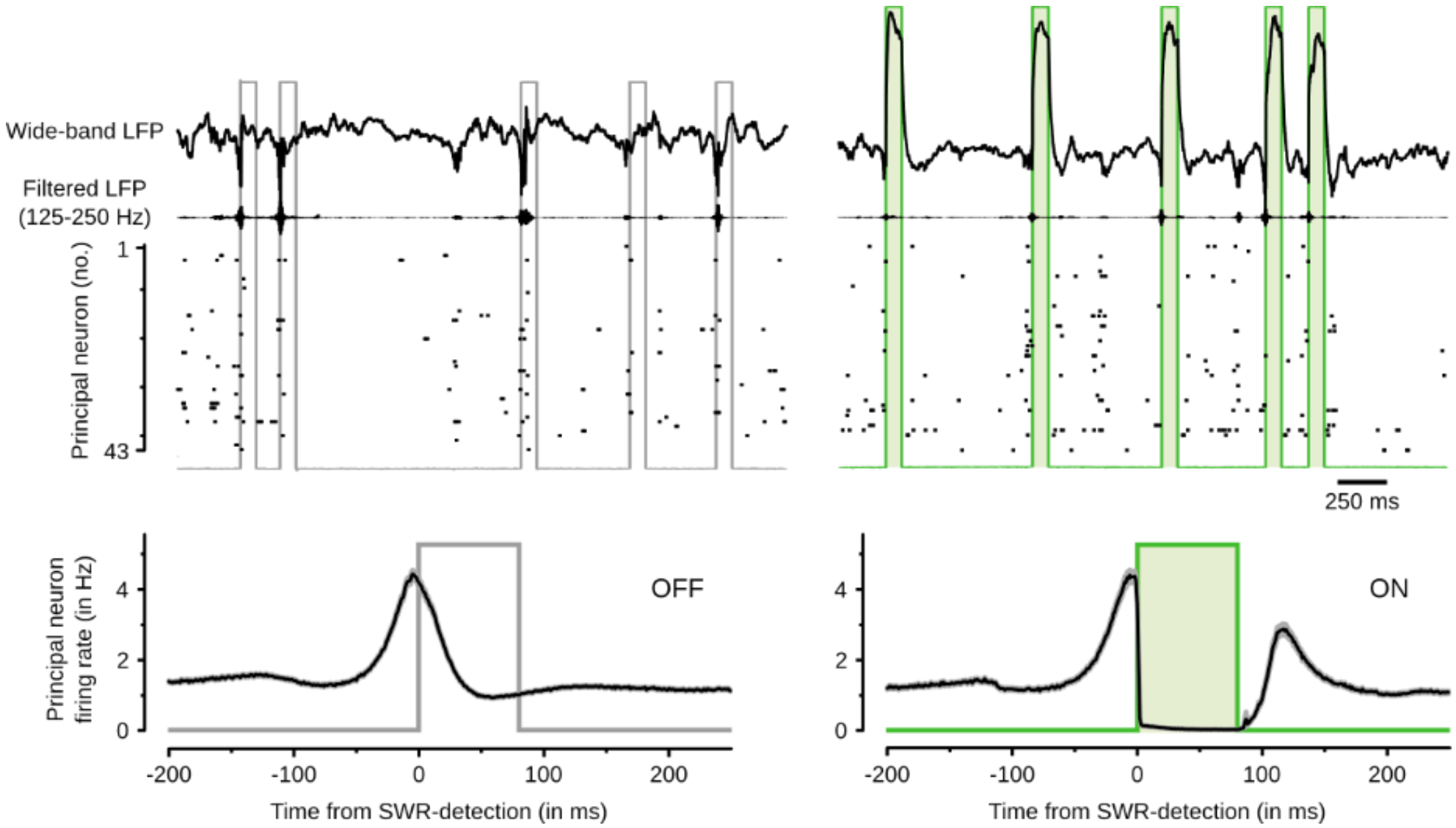


Optogenetic silencing of CamKII-positive cells using ArchT



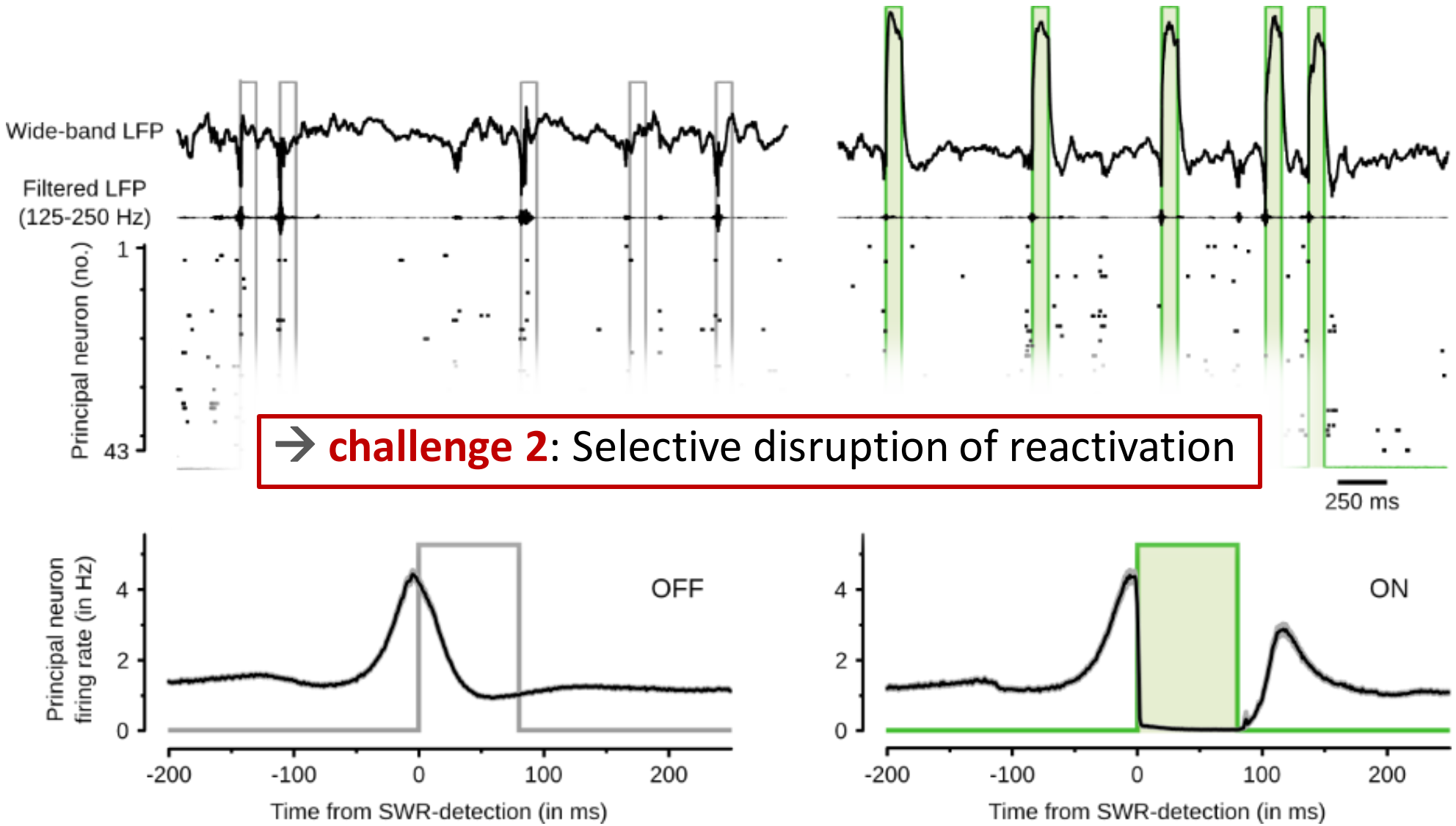


Selective disruption of reactivation: *optogenetic SWR silencing*



OFF: *n* = 1,988 neurons (from 43 sessions)
ON: *n* = 1,527 neurons (from 37 sessions)

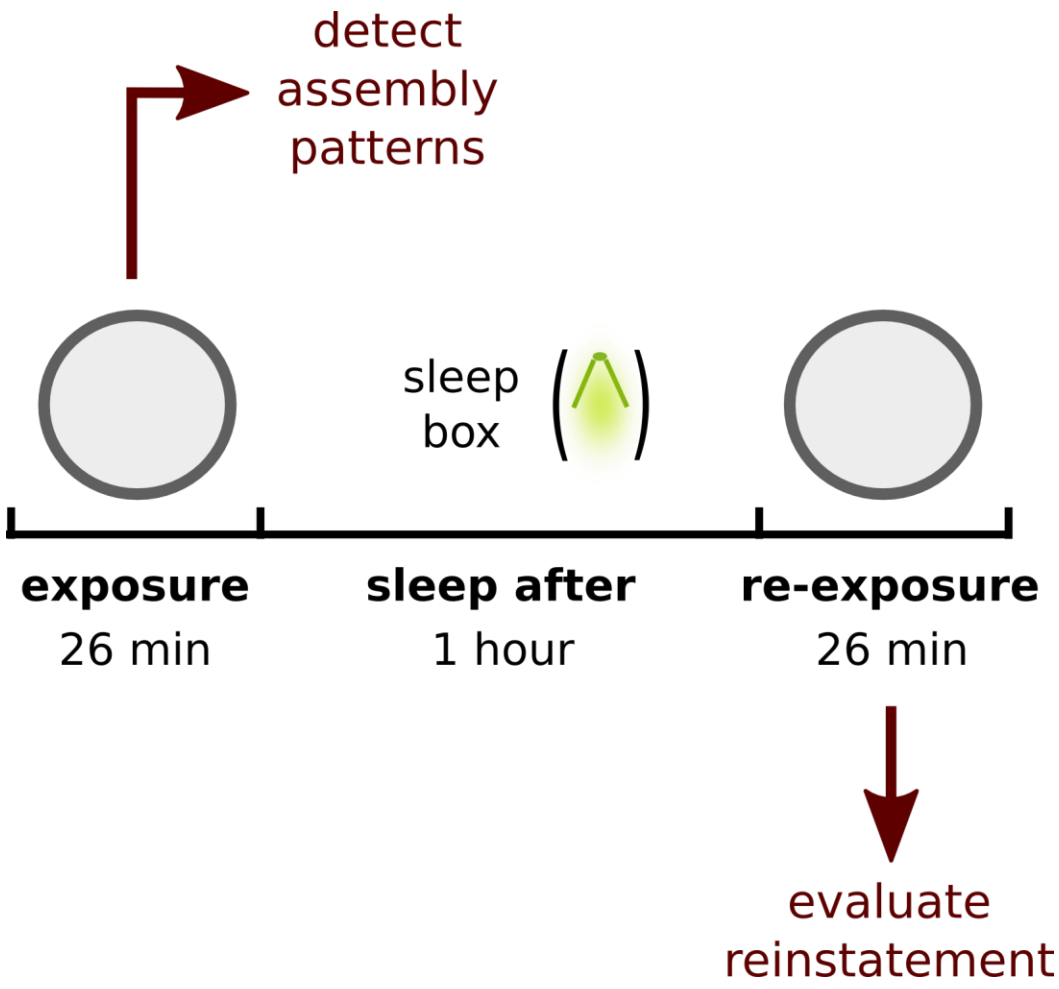
Selective disruption of reactivation: *optogenetic SWR silencing*



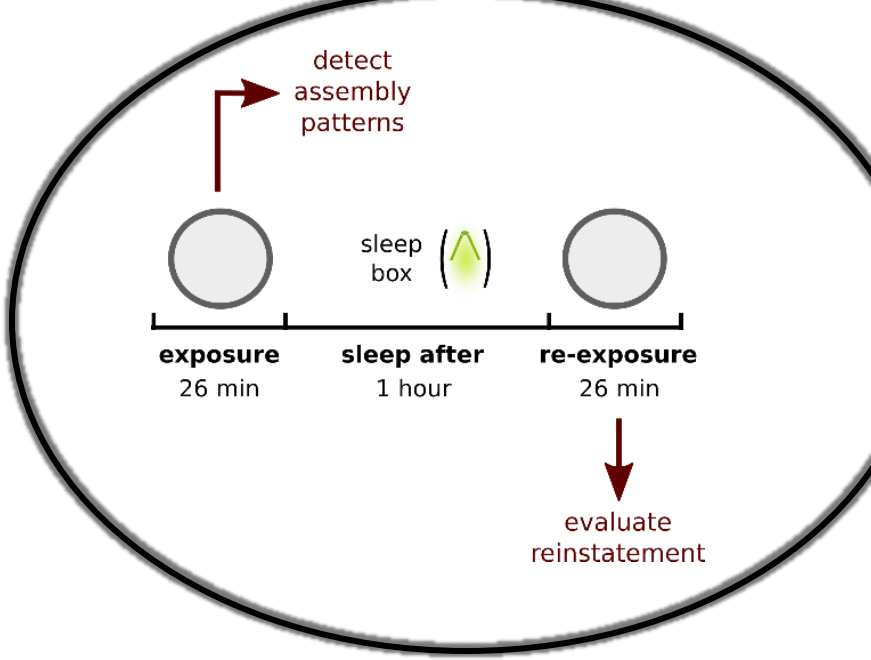
→ **challenge 2**: Selective disruption of reactivation

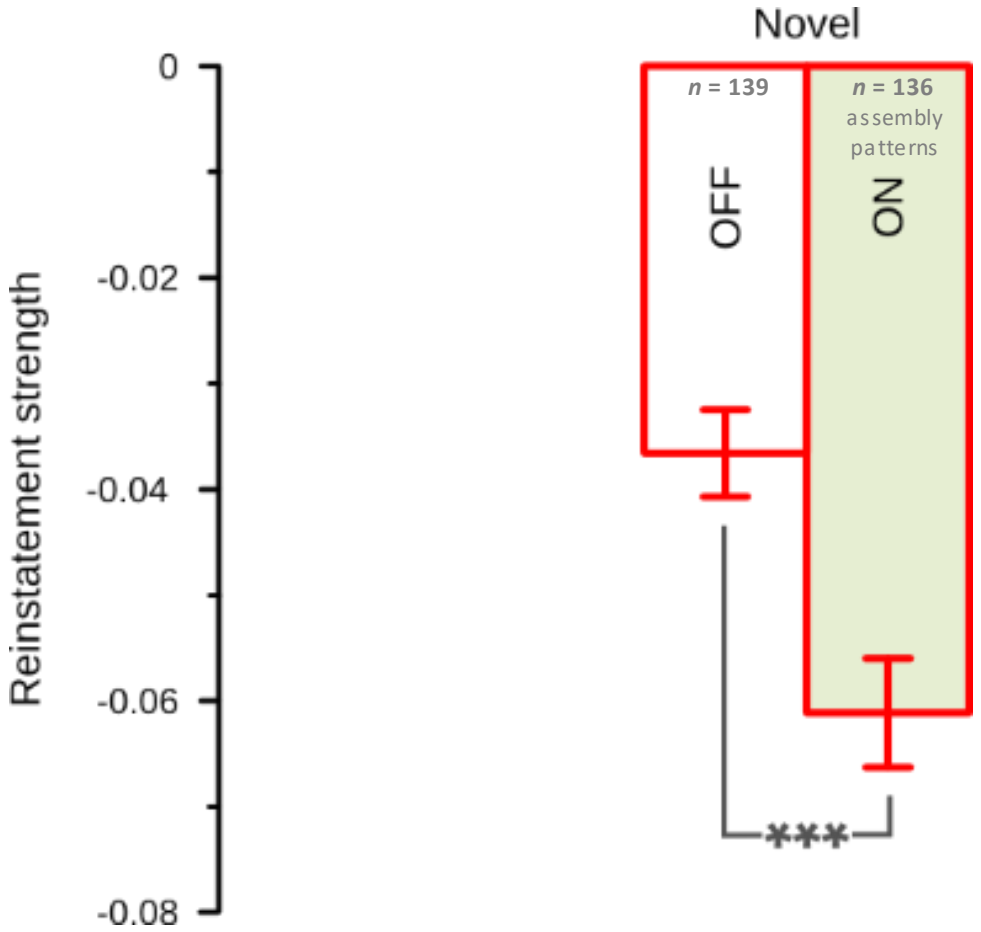
OFF: *n* = 1,988 neurons (from 43 sessions)
ON: *n* = 1,527 neurons (from 37 sessions)

Experimental protocol - (*causation*)



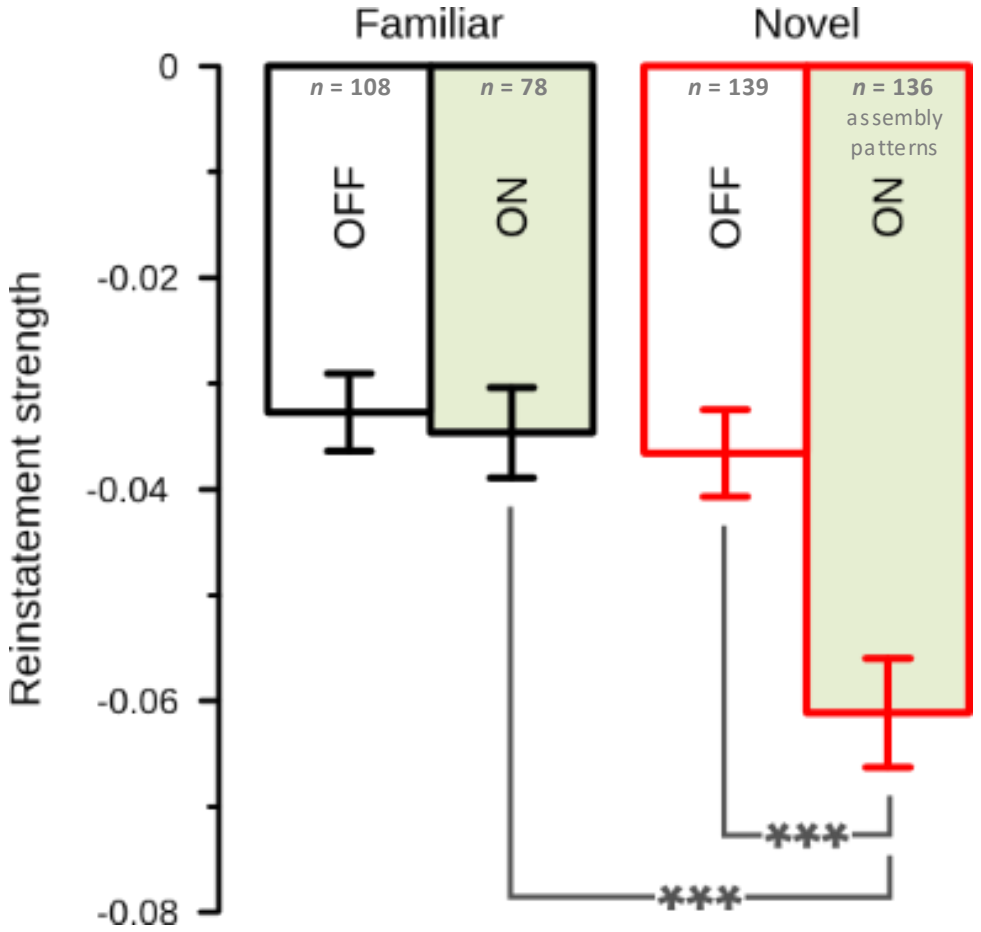
SWR-silencing impairs assembly pattern reinstatement



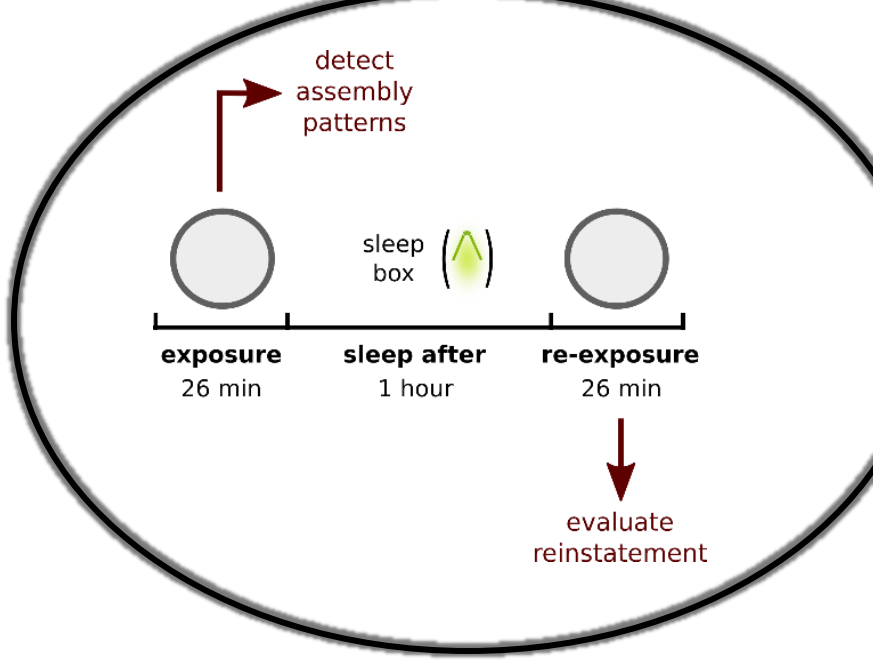


(based on 50 recording-blocks from 8 mice)

SWR-silencing impairs assembly pattern reinstatement

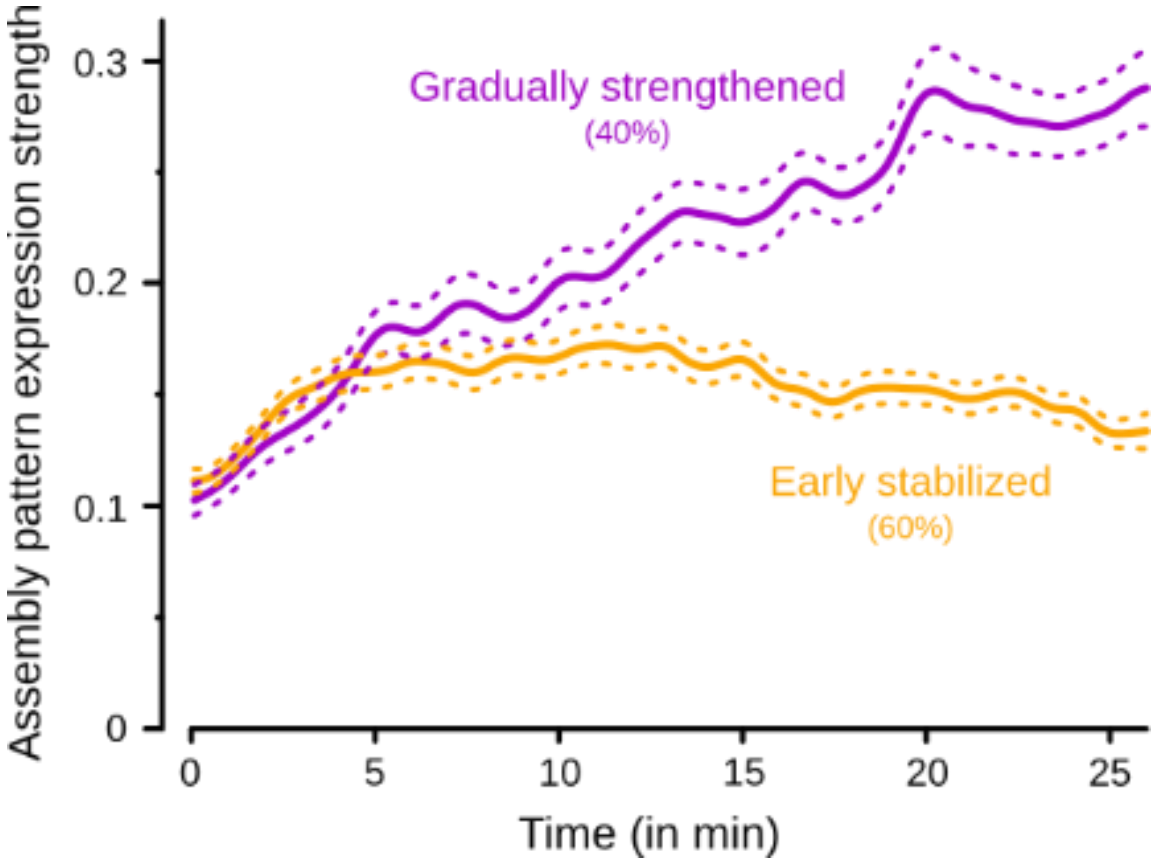


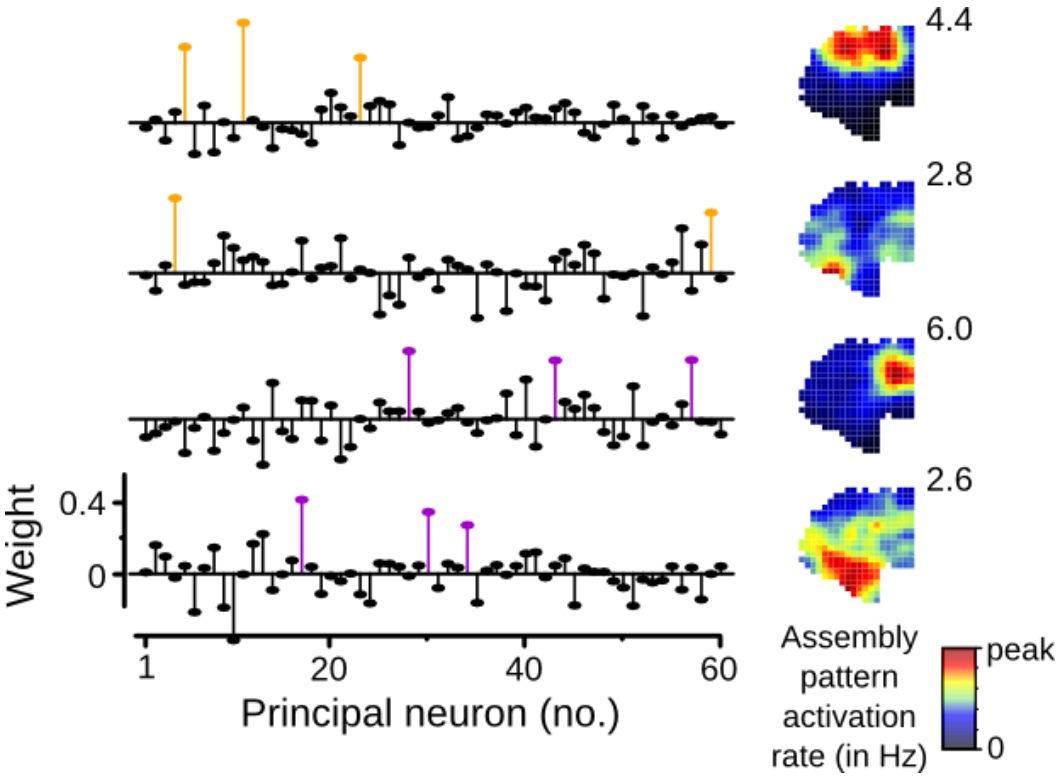
interaction SWR-silencing x enclosure type:
$F(1,318) = 5.05$, $P < 0.05$



(based on 80 recording-blocks from 8 mice)

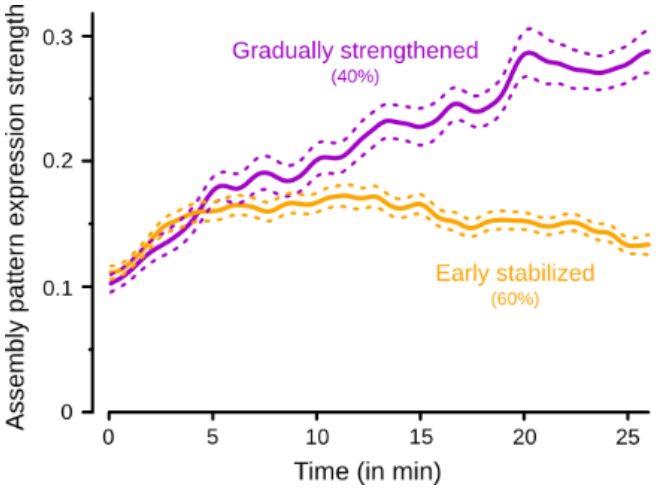
Only stability of gradually strengthened patterns requires offline reactivation

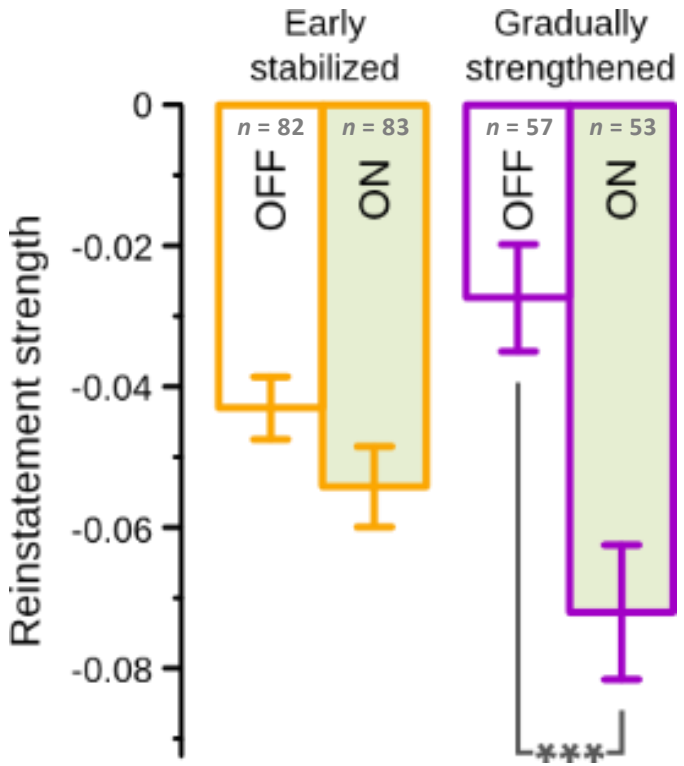




Gradually strengthened: *n* = 134 assembly-patterns
Early stabilized: *n* = 201 assembly-patterns
(based on 50 recording-blocks from 8 mice)

Only stability of gradually strengthened patterns requires offline reactivation

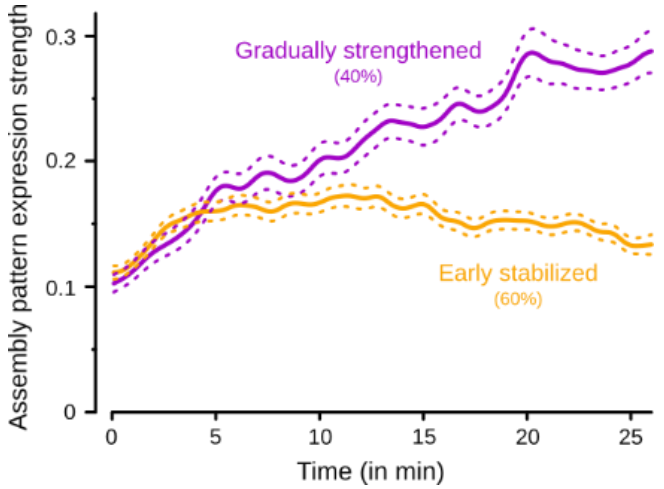


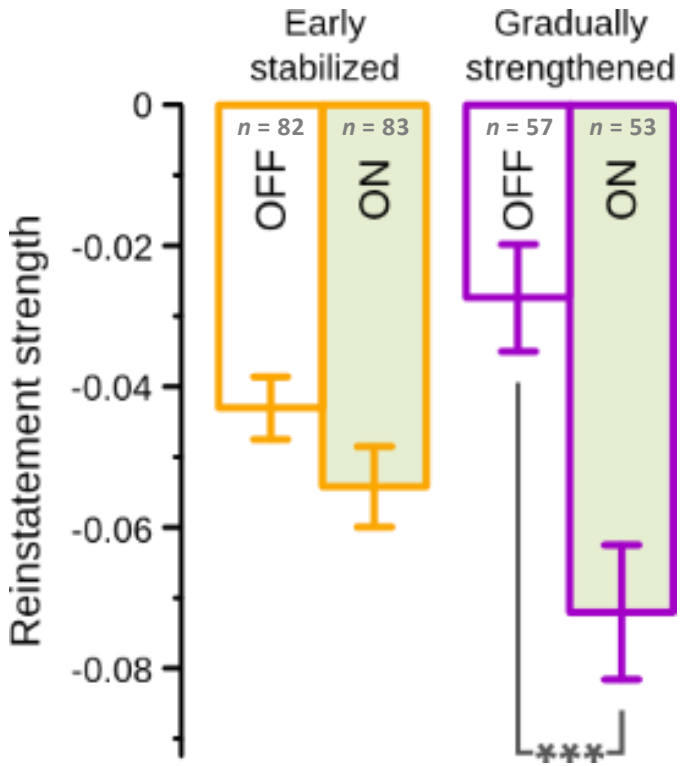


interaction SWR-silencing x pattern type:
$F(1,271) = 6.28$, $P < 0.05$

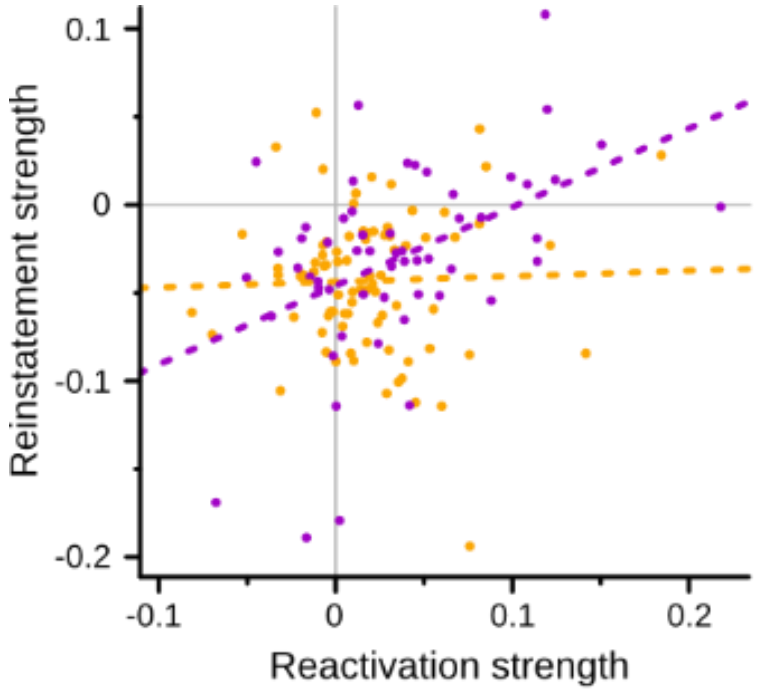
(based on 50 recording-blocks from 8 mice)

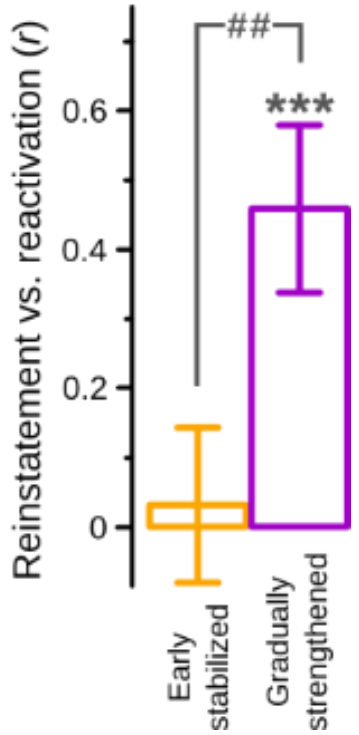
Only stability of gradually strengthened patterns requires offline reactivation





interaction SWR-silencing x pattern type:
$F(1,271) = 6.28$, $P < 0.05$





(based on 50 recording-blocks from 8 mice)

One-sentence summary

The stability of “Hebbian-like” cell assembly patterns, which are gradually strengthened during their initial expression, depends on their offline reactivation.

Acknowledgements

Dupret lab
David Dupret
Stephanie Trouche
Colin McNamara
Natalia Campo-Urriza
Vitor Lopes dos Santos
Alvaro Tejero-Cantero
Claire Bratley
Pavel Perestenko

Vadim Koren
Helen Barron
Alexander Morley
Mohamady El-Gaby
Stephen McHugh

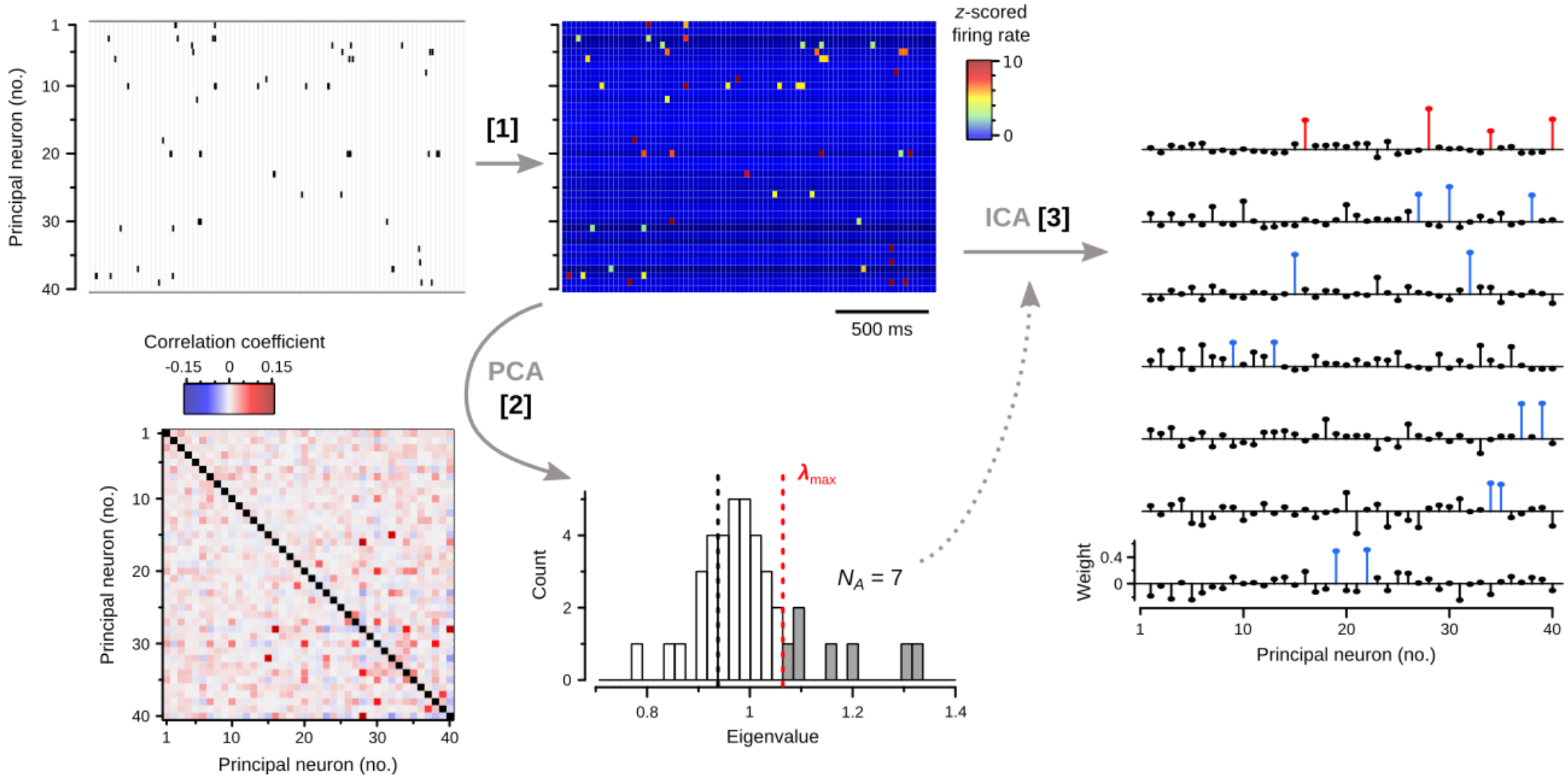
Visualizing tetrode tracks
Ben Micklem
Linda Katona

Research support
Jane Janson
Liz Norman
Lisa Conyers
Katharine Whitworth
Kristina Wagner

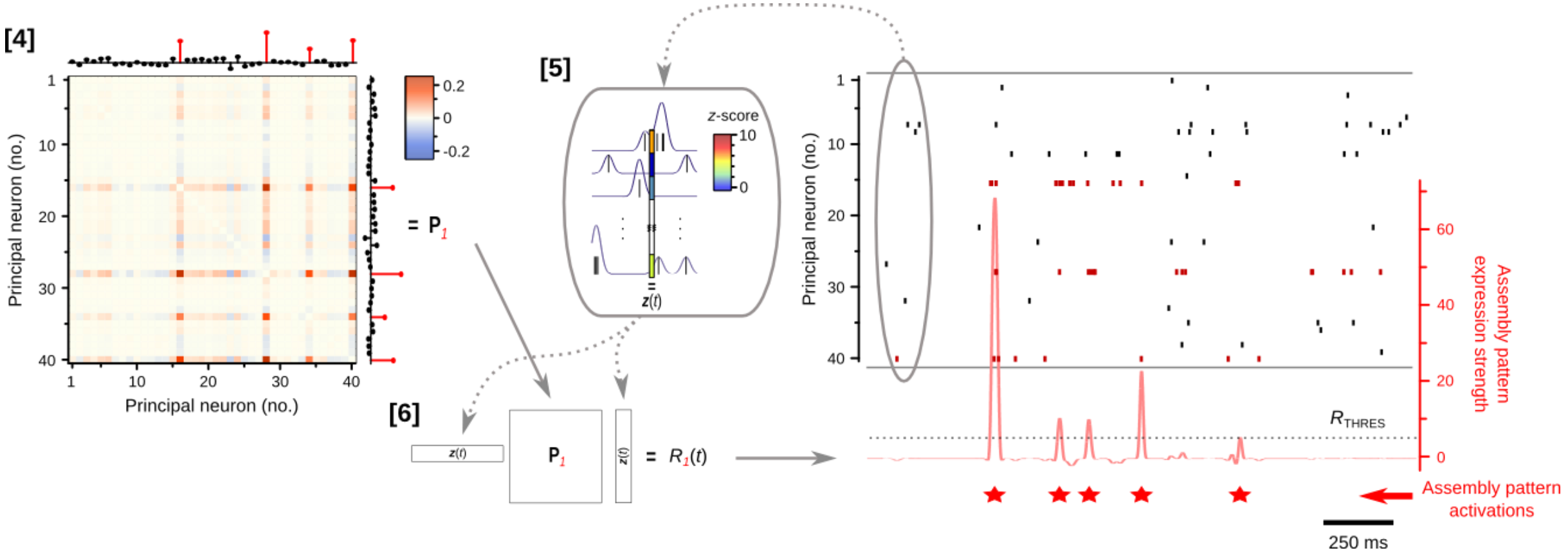
Heidelberg
Kevin Allen (real-time SWR detection)

More details: van de Ven et al. (2016) *Neuron* **92**, pp. 968-974 [+ video abstract online]

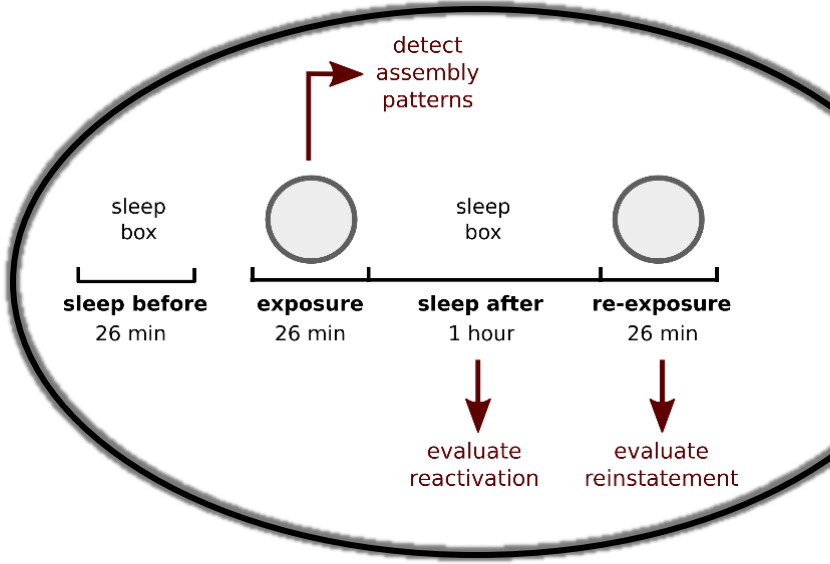
Assembly pattern identification

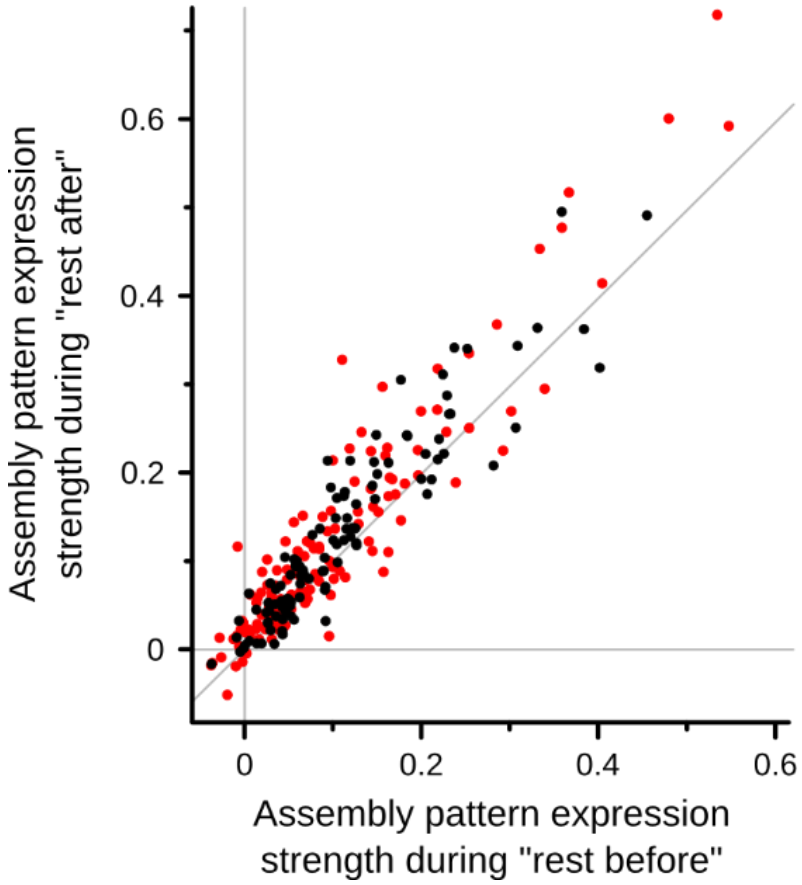


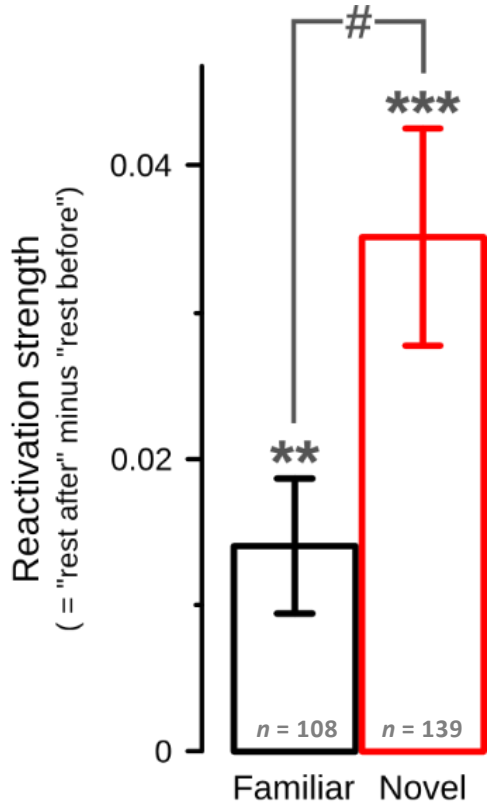
Assembly pattern tracking



Assembly pattern reactivation

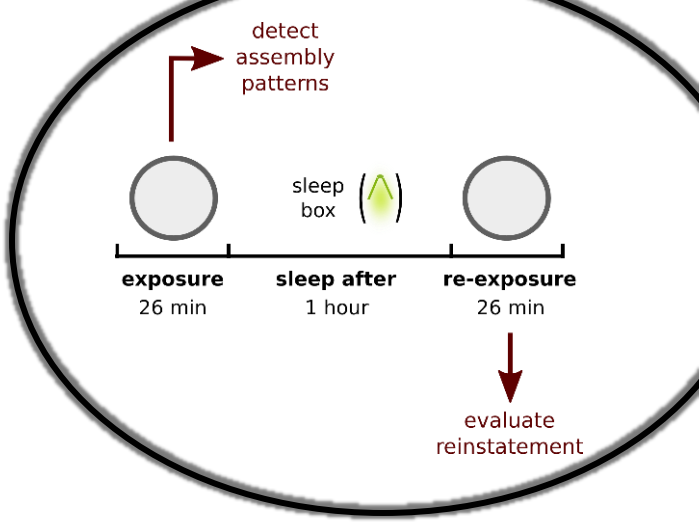


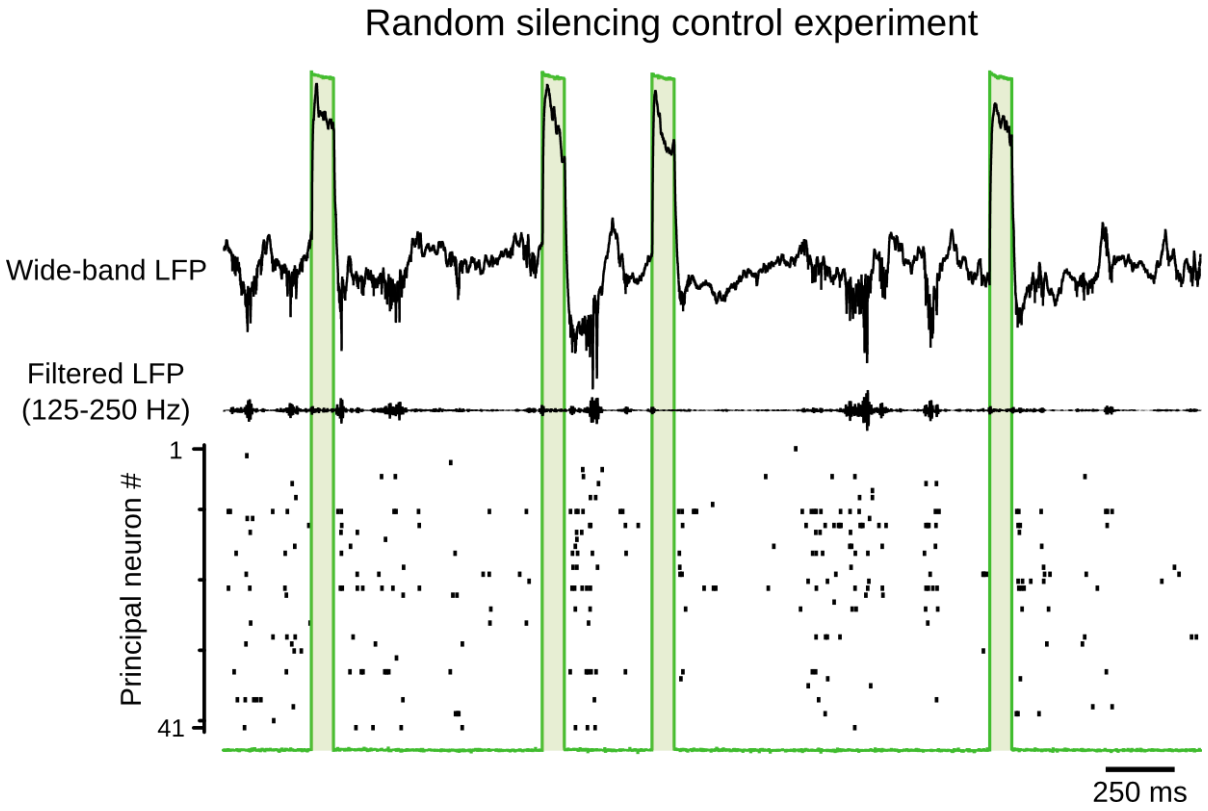


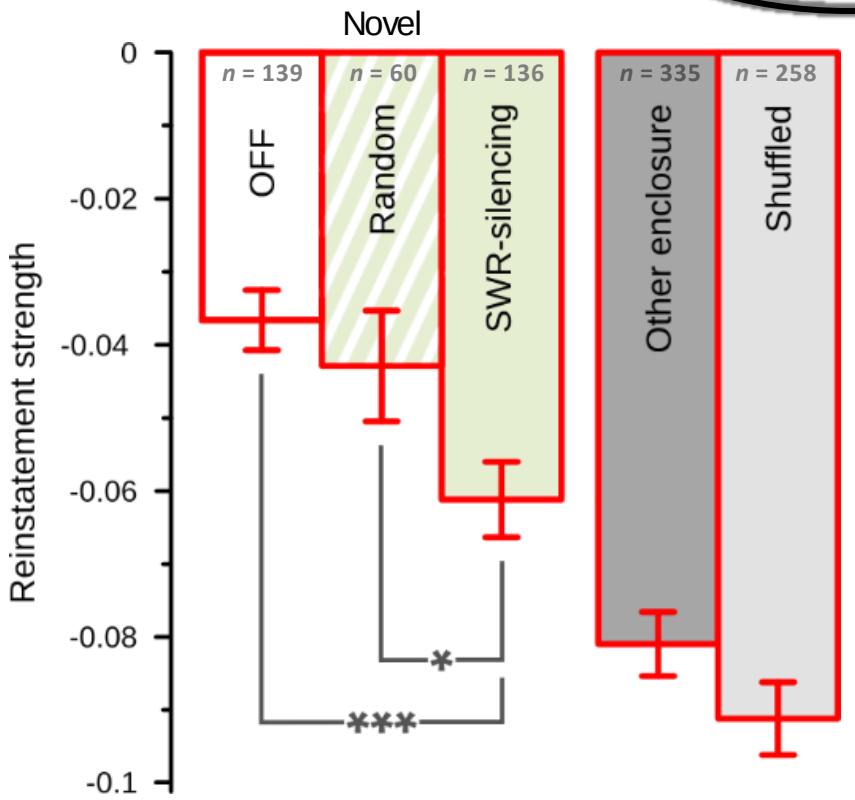


(based on 43 recording-blocks from 8 mice)

Control experiment: random silencing

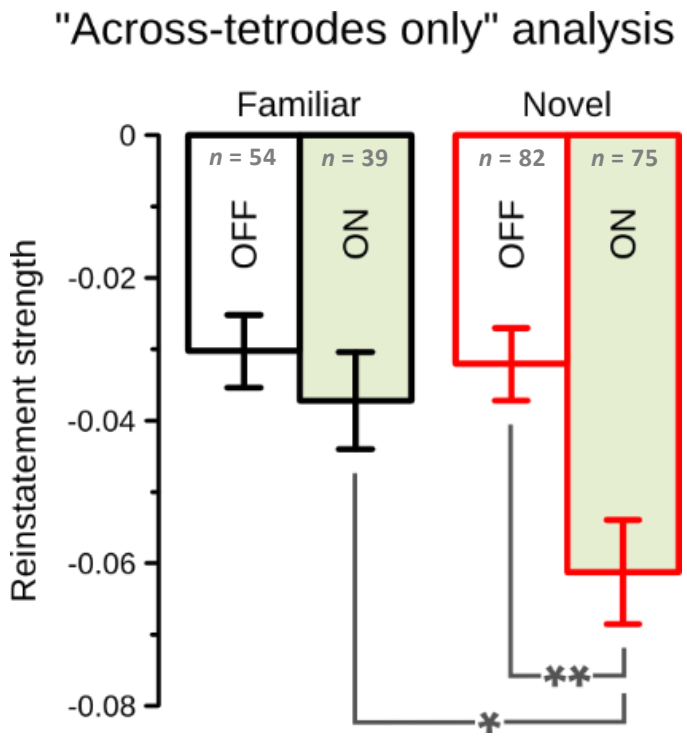


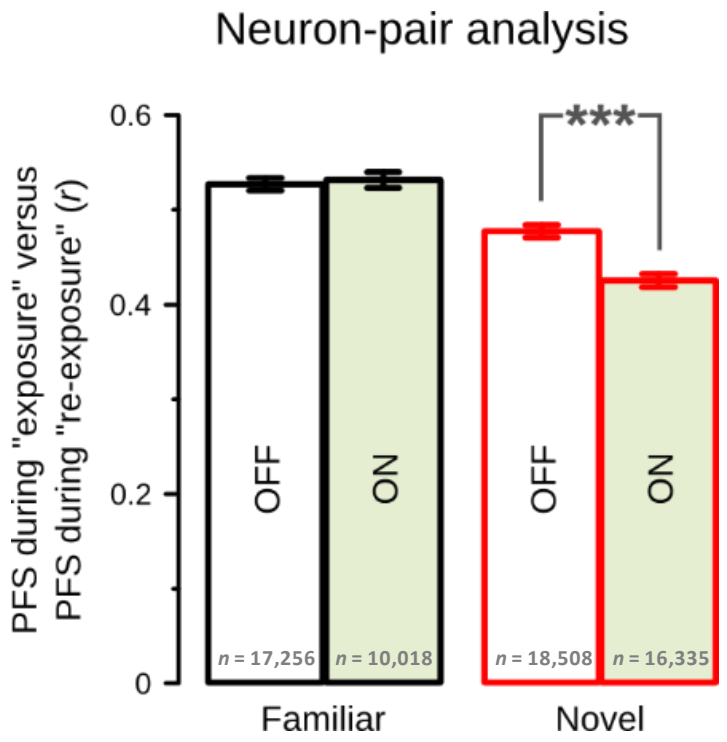


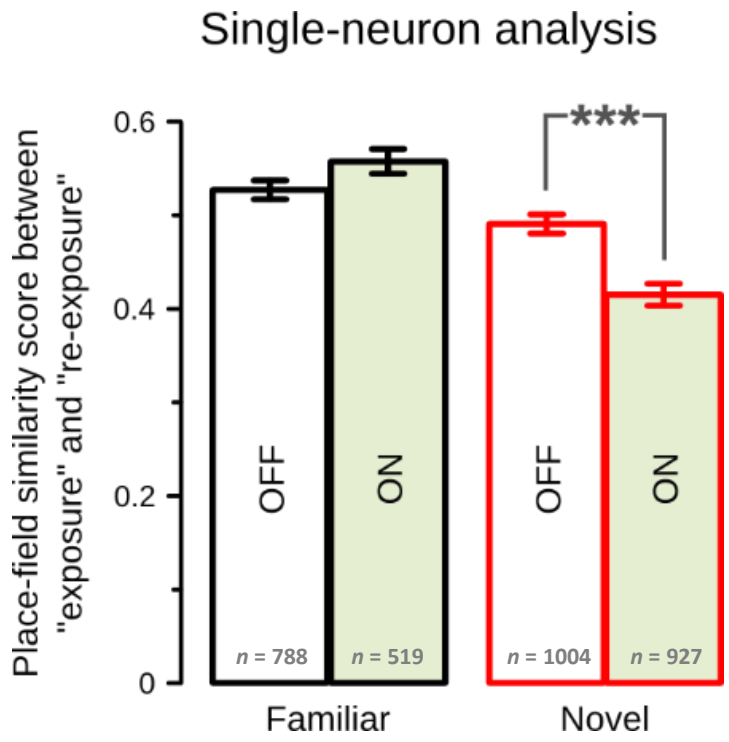


(based on 63 recording-blocks from 8 mice)

Effect of SWR-silencing: control analyses







(based on 80 recording-blocks from 8 mice)