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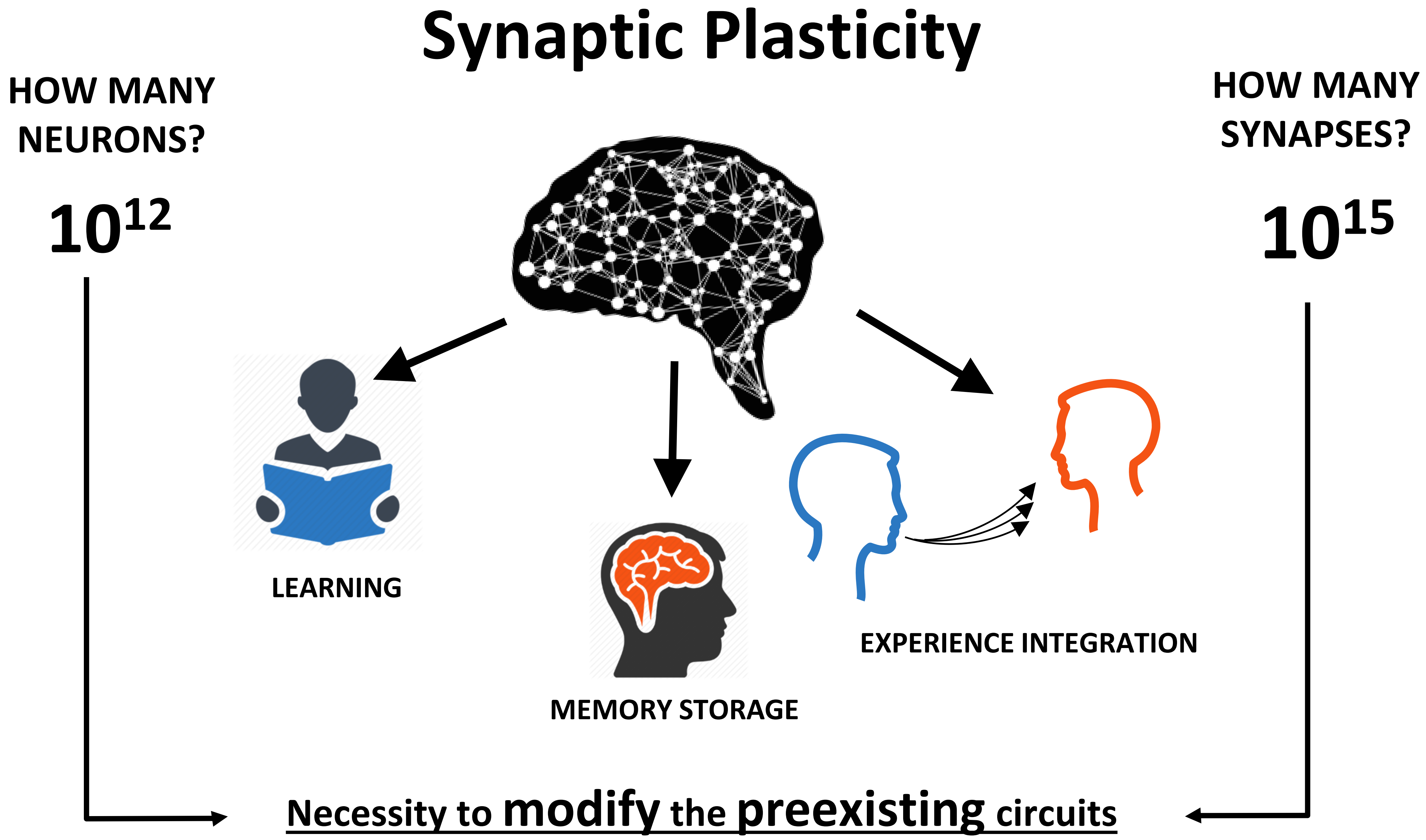
Current Opinion in Neurobiology

Adult neurogenesis beyond the niche: its potential for driving brain plasticity

Kurt A Sailor[1,2], Alejandro F Schinder[3] and Pierre-Marie Lledo[1,2]

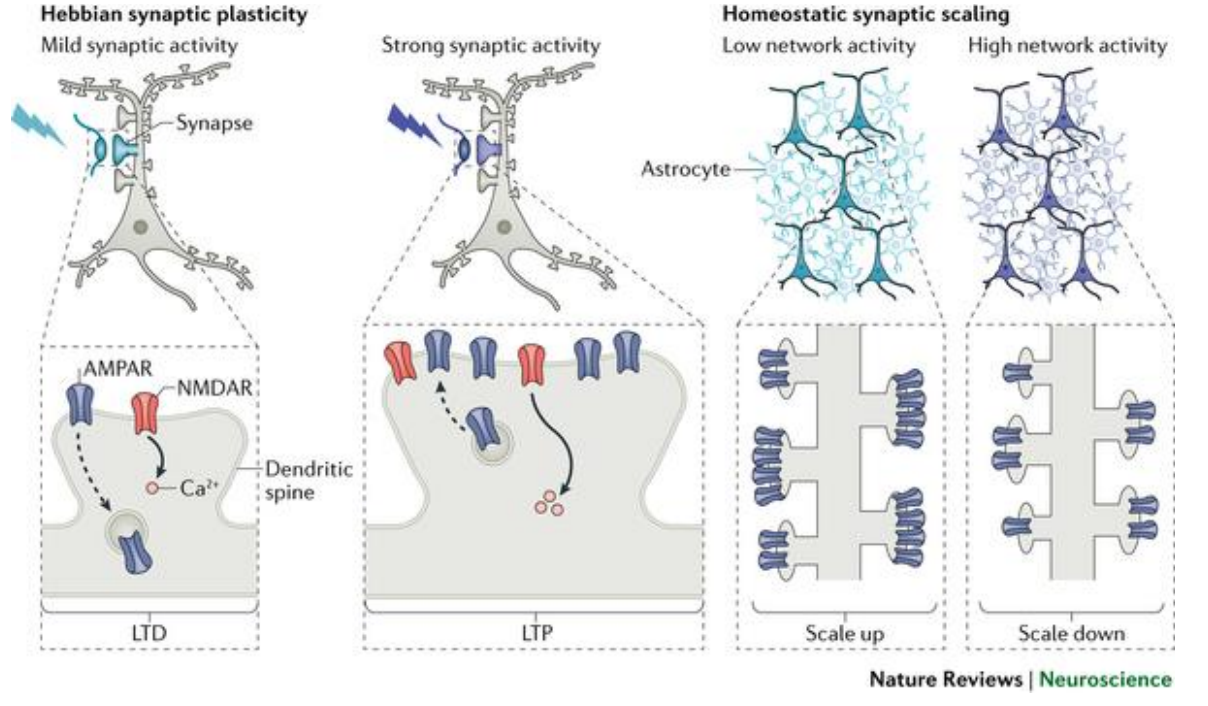
CrossMark

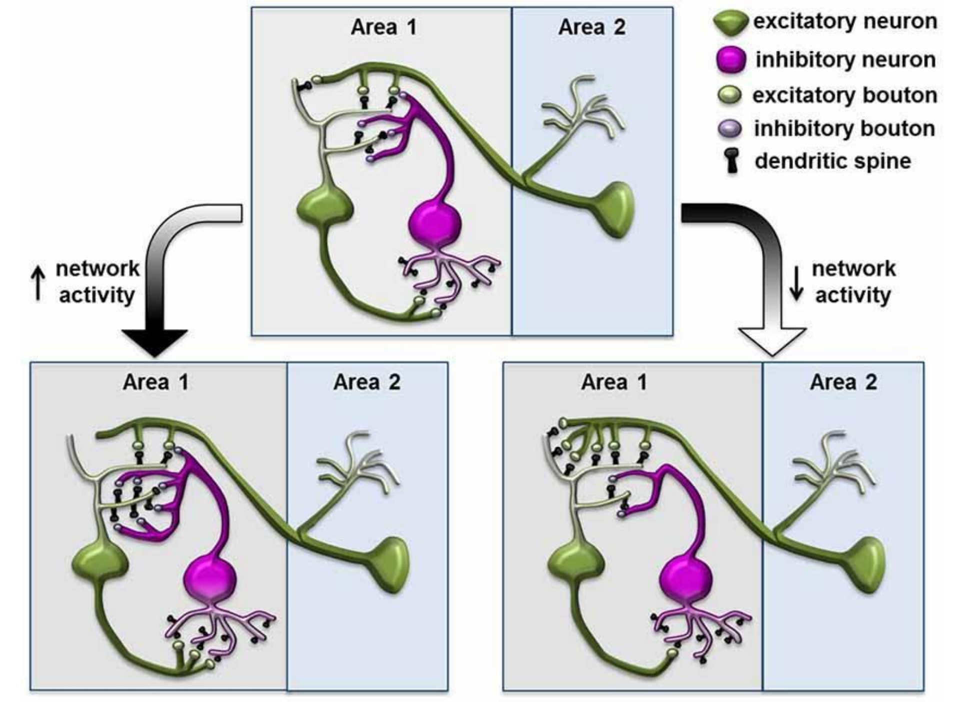
Bozkurt Döndü, Mulè Francesca, Rossi Fabiana


Synaptic Plasticity
HOW MANY NEURONS?
10^{12}
HOW MANY SYNAPSES?
10^{15}
LEARNING
MEMORY STORAGE
EXPERIENCE INTEGRATION
Necessity to modify the preexisting circuits

Hebbian Plasticity: Rapid modification of pre/postsynaptic efficacy in a long-lasting manner via NMDAR and AMPAR

Homeostatic Plasticity: Stabilization of networks activity





Structural and **Functional Plasticity:**

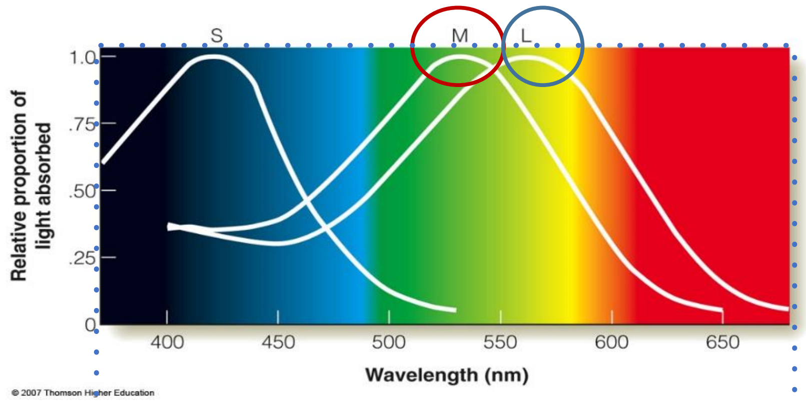
↓ Remodelling of synaptic elements

↓ Rearrangement of existing neurons' connection to restore a damaged area of the brain

Emergence of Novel Color Vision in Mice Engineered to Express a Human Cone Photopigment

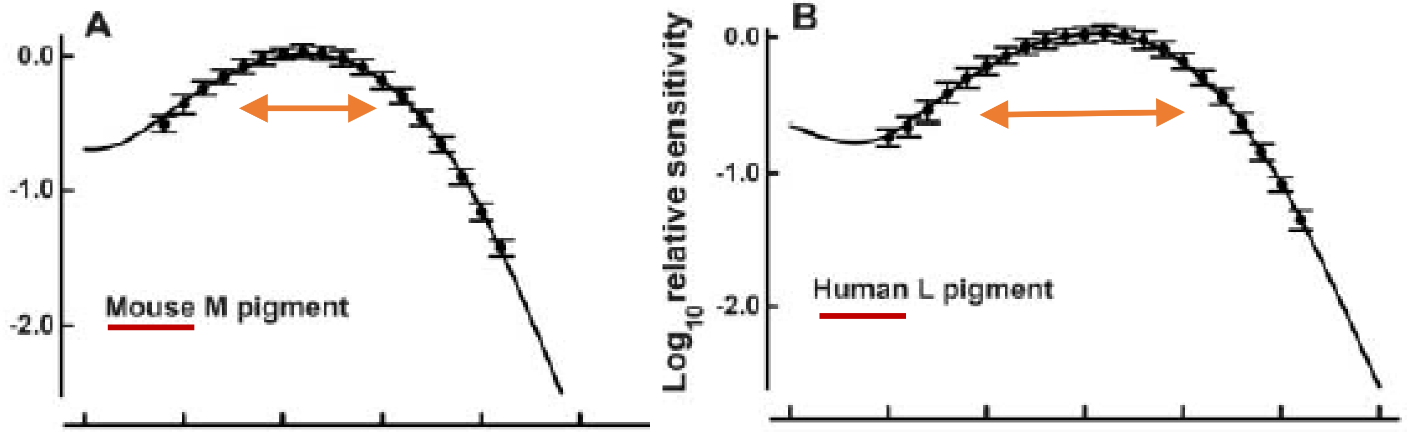
Gerald H. Jacobs,[1]* Gary A. Williams,[1] Hugh Cahill,[2,3,4] Jeremy Nathans[2,3,4,5]

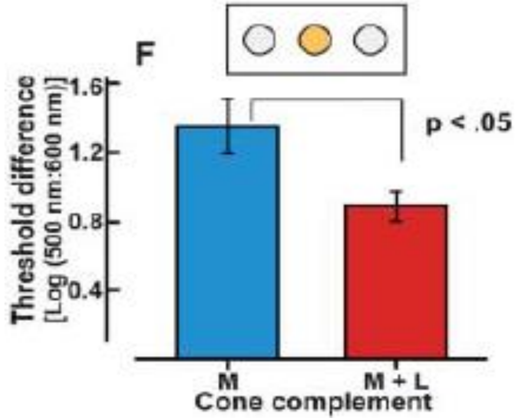
Does the mammalian brain sufficiently plastic to compare and integrate new sensory input?



-linked photopigment genes

+ **L** pigment cDNA =





Nervous system is able to discriminate between new and existing stimuli

Transient and Persistent Dendritic Spines in the Neocortex In Vivo

Anthony J.G.D. Holtmaat,[1]
Joshua T. Trachtenberg,[1,3] Linda Wilbrecht,[1]
Gordon M. Shepherd,[1] Xiaoqun Zhang,[1]
Graham W. Knott,[2] and Karel Svoboda[1,*]
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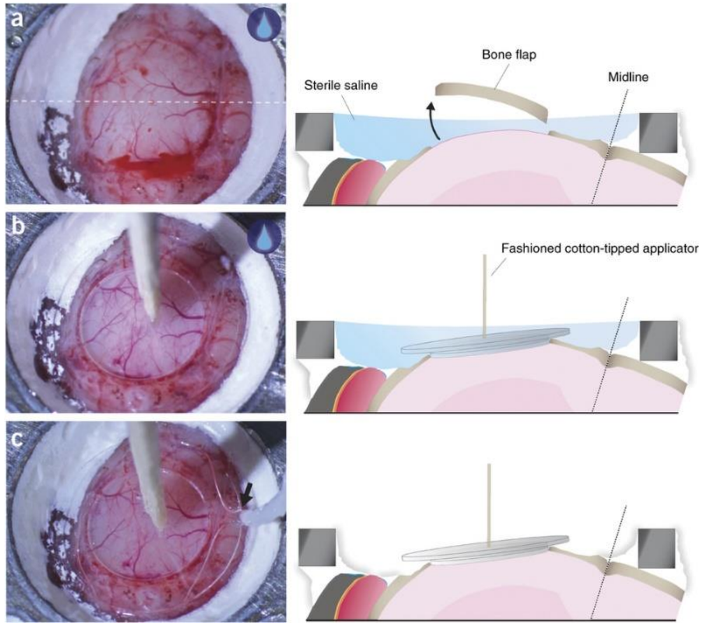
Rue du Bugnon 9
CH 1005 Lausanne
Switzerland

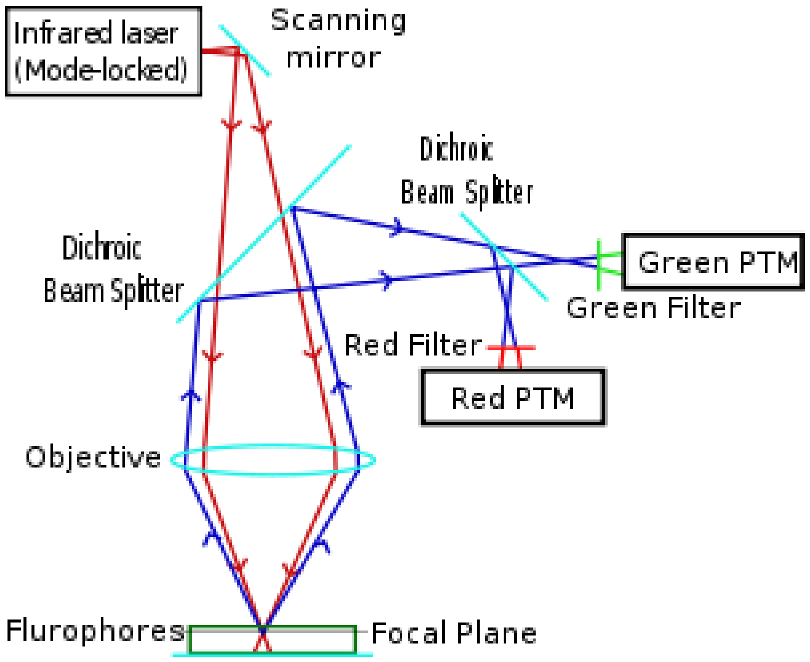
In a subset of **pyramidal neurons** in:
Layer 2/3
Layer 5
Layer 6

EGFP

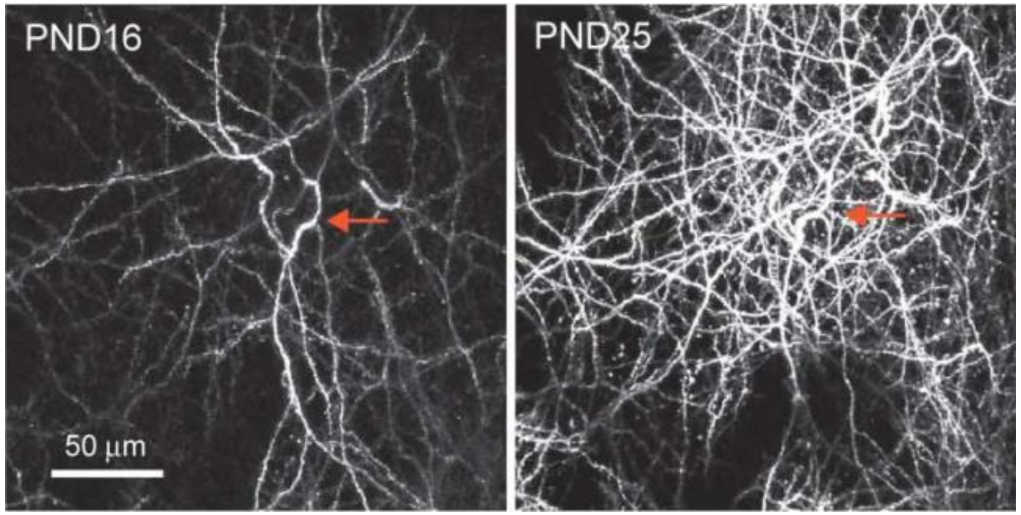
Fixed sections

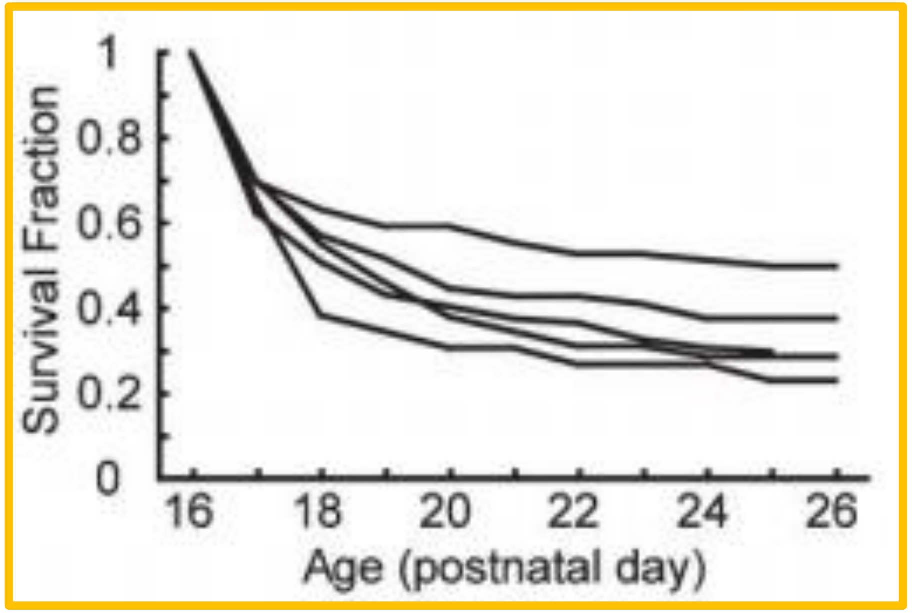
In vivo



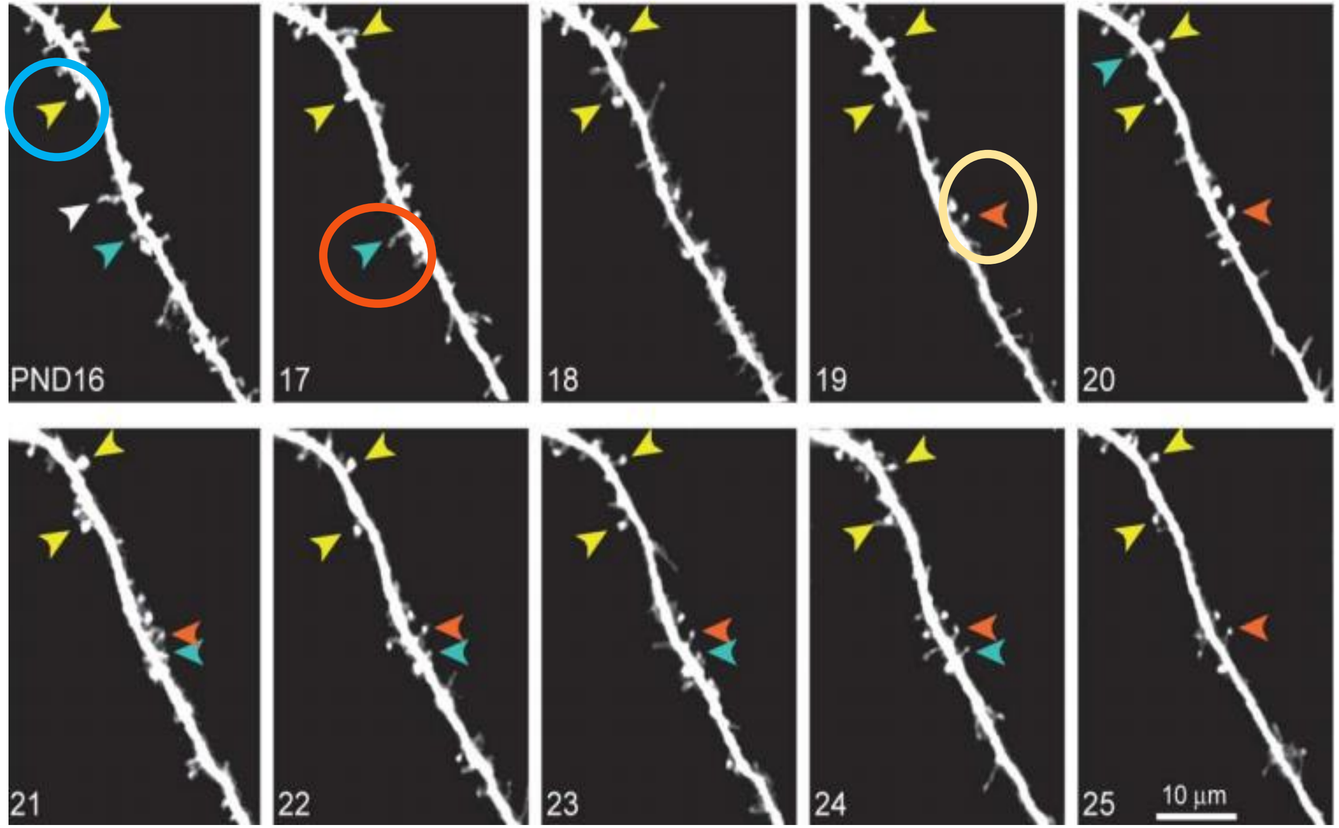


How Does Spine Stability Change during development?

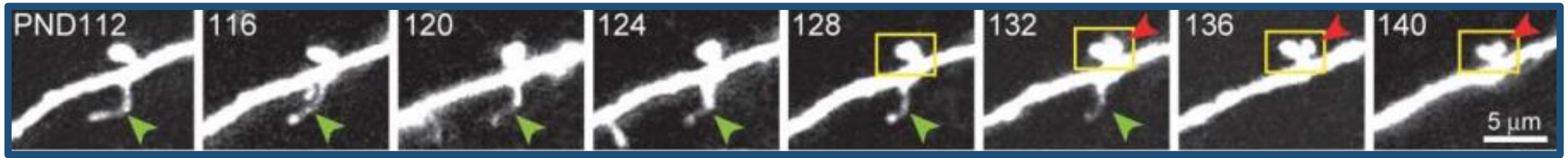




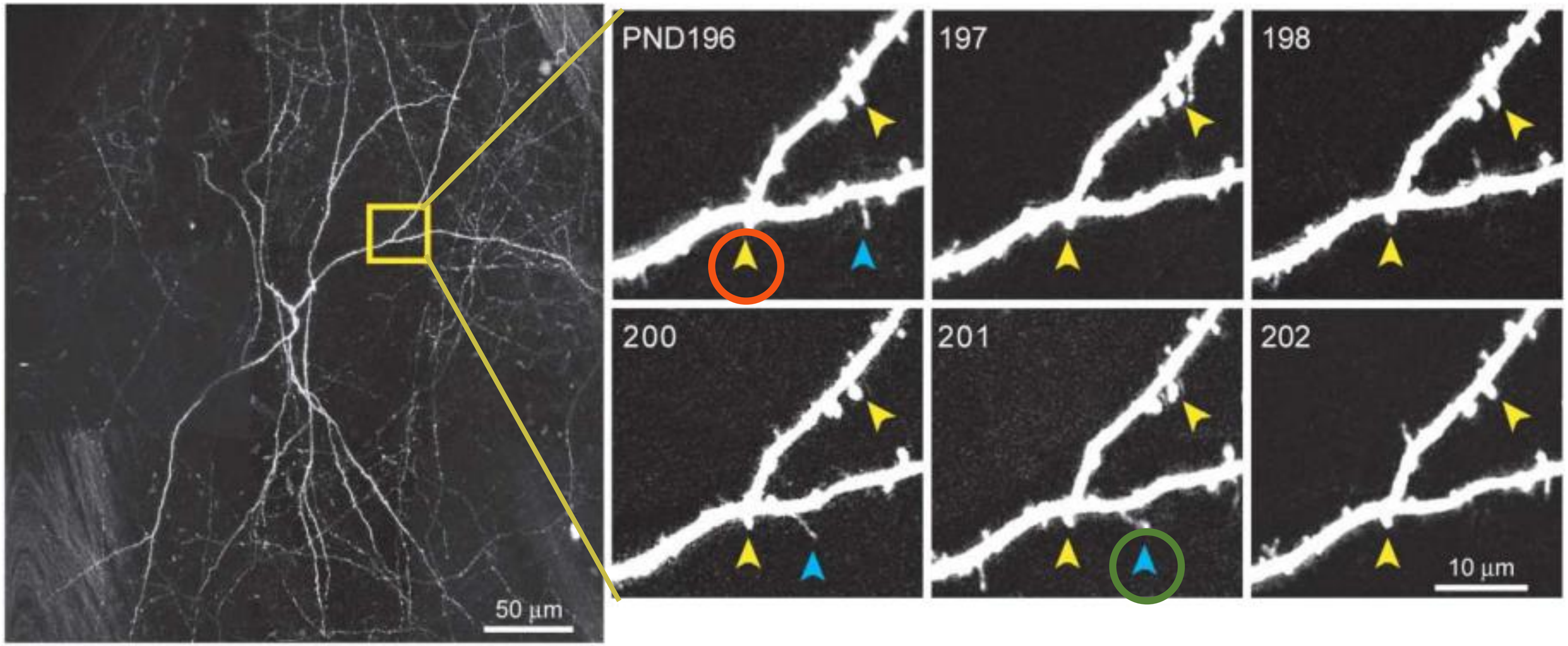
Yellow: Persistent spines
Blu: Transient spines
Red: New Persistent spines



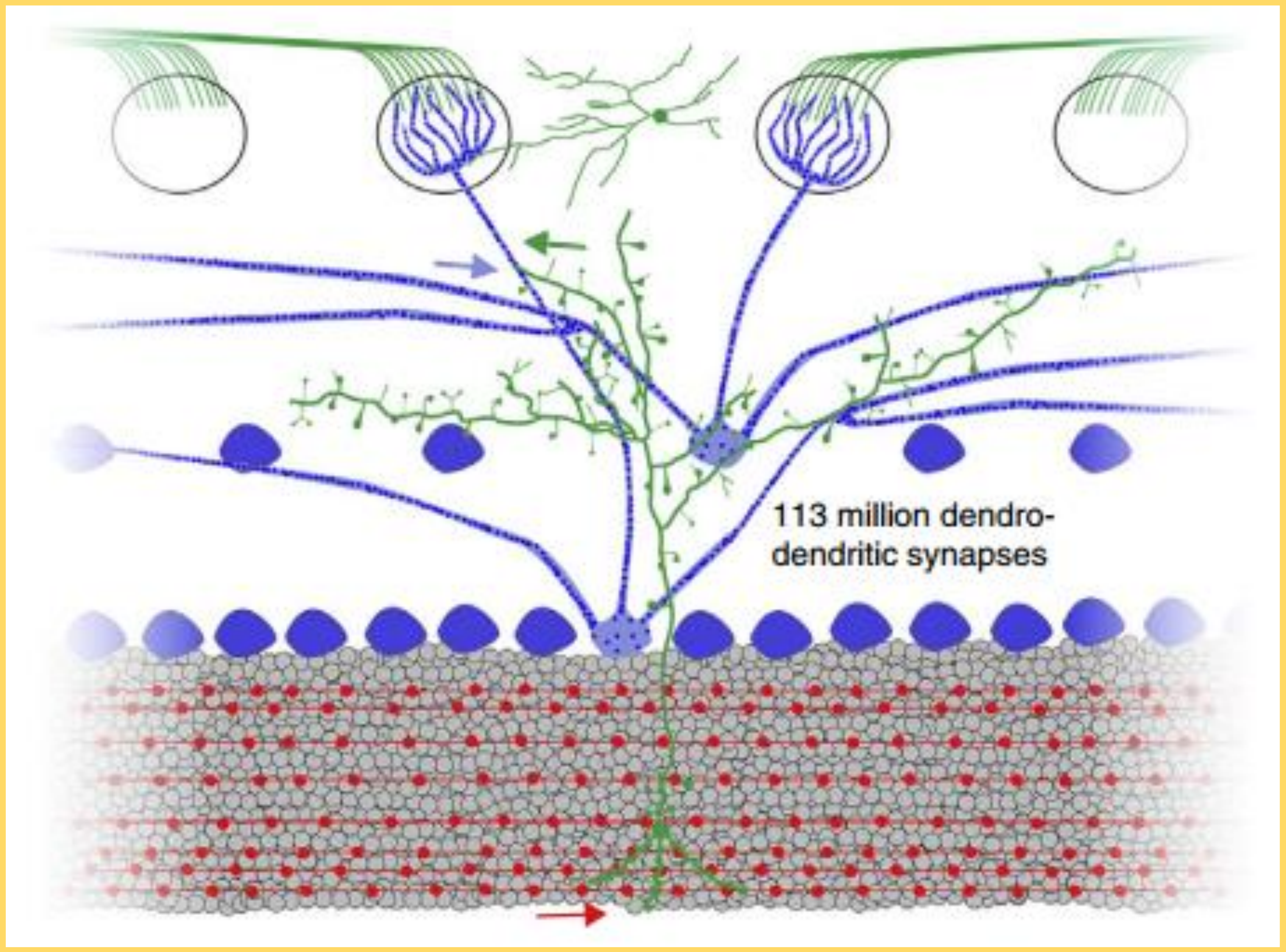
Could spine plasticity be regulated by age in the adult brain?



Transient and **Persistent** spines constitute two different subpopulation



How does adult neurogenesis promote structural plasticity in the olfactory bulb?



Mitral and Tufted cells (MC/TC)

synapse *three major neuronal populations* with intense postnatal neurogenesis

Olfactory sensory neurons

Periglomerular cells

Granule cells

Dendro-dendritic synapse

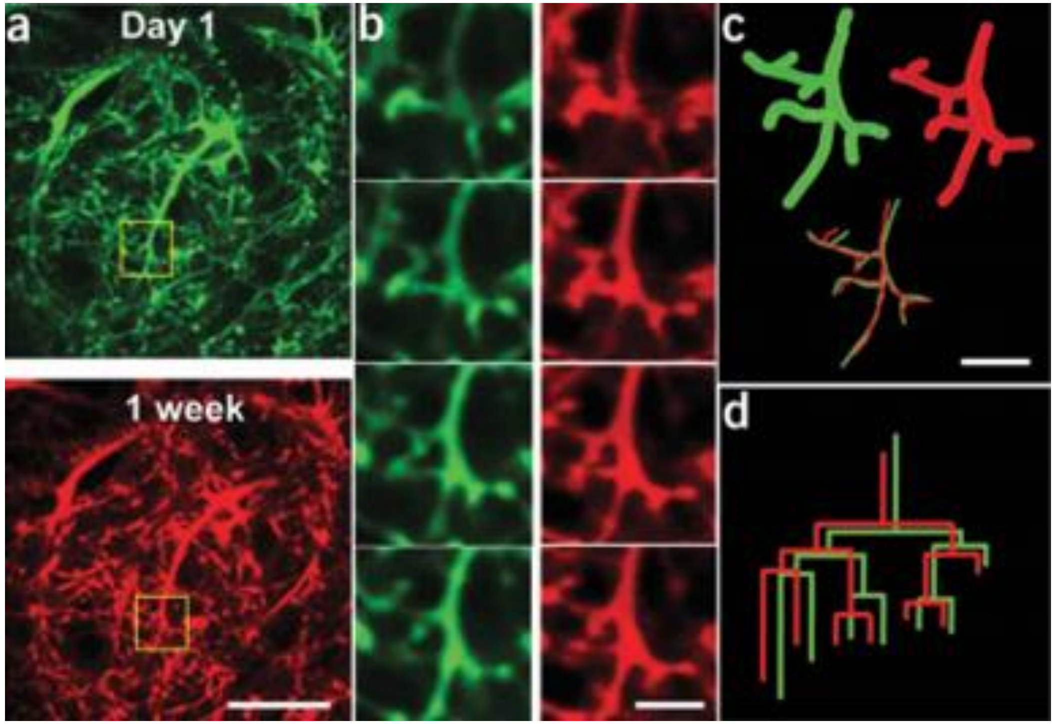
Do M/T cells have similar dynamics in their glomerular dendritic structure?

ARTICLES

nature neuroscience

Dendritic stability in the adult olfactory bulb

Adi Mizrahi & Lawrence C Katz



Despite the **ongoing synaptogenesis** within **glomeruli**, the **apical dendrites** of **M/T cells** remain **stable** over both *short* (24 h) and *long* (1 week) *intervals*

Dendritic stability as a ***structural scaffold*** to maintain the organization of local circuits

CellPress

Neuron
Article

Persistent Structural Plasticity Optimizes Sensory Information Processing in the Olfactory Bulb

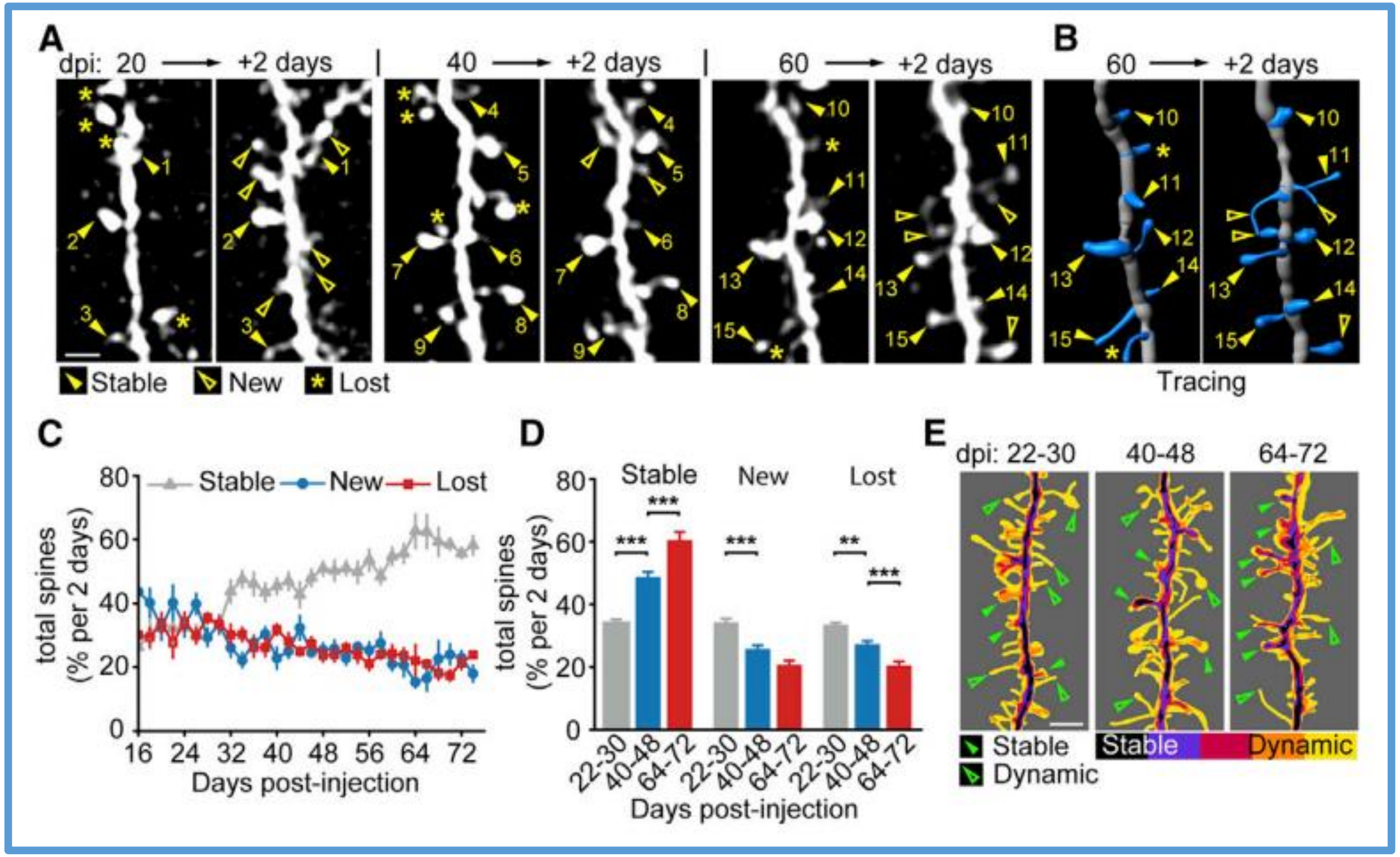
Kurt A. Sailor,[1,2,3,4,7,10] Matthew T. Valley,[1,2,9,10] Martin T. Wiechert,[1,2] Hermann Riecke,[8] Gerald J. Sun,[3,4] Wayne Adams,[8] James C. Dennis,[8] Shirin Sharafi,[1,2] Guo-li Ming,[3,4,5,6,7] Hongjun Song,[3,4,5,7,*] and Pierre-Marie Lledo[1,2,*]

Spines turnover in Granule cells in the olfactory bulb

Synaptic reorganization no MC/TC GABAergic post synaptic structures

- **Oncoretrovirus injection into the RMS/SVZ** → to express GFP in adult-born (**P70**) and early postnatal (**P14**) GCs
- **Injection of floxed lentivirus** expressing a **gephyrin-teal fusion** in the OB of Tbet-Cre mice → to label MC/TC **inhibitory synapses**
- **Two-photon imaging**

Adult-Born GC Developmental Spine Dynamics



Initial stage of GC formation

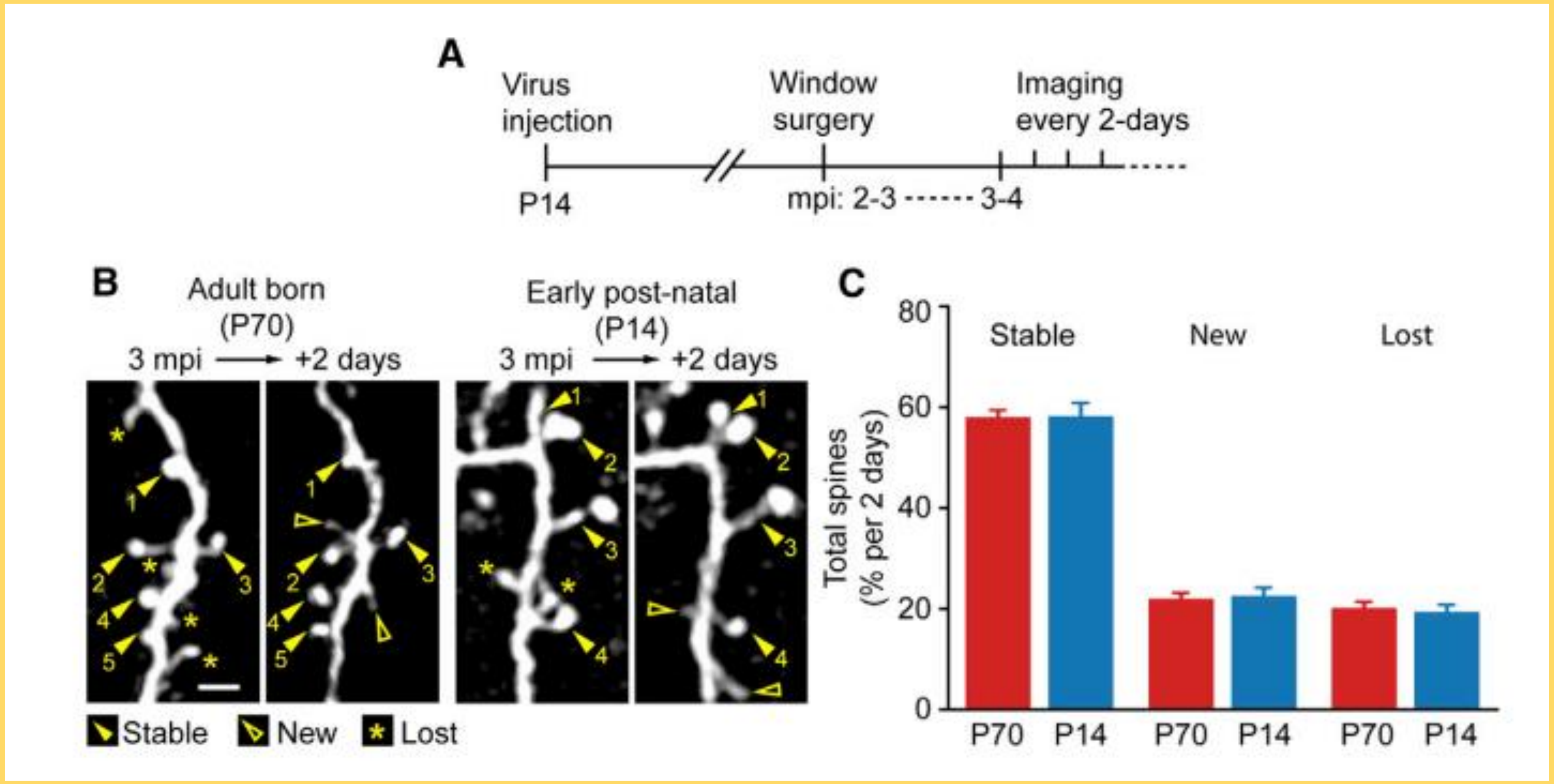
High number of new and lost spines

After initial period

New and lost spines number ***decreases***

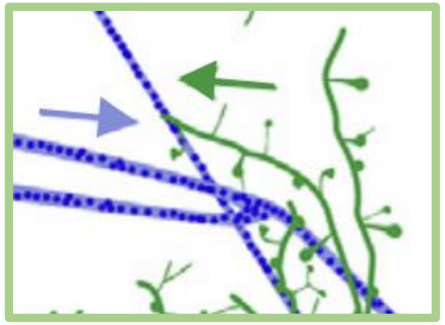
Stable spines gradually ***increase***

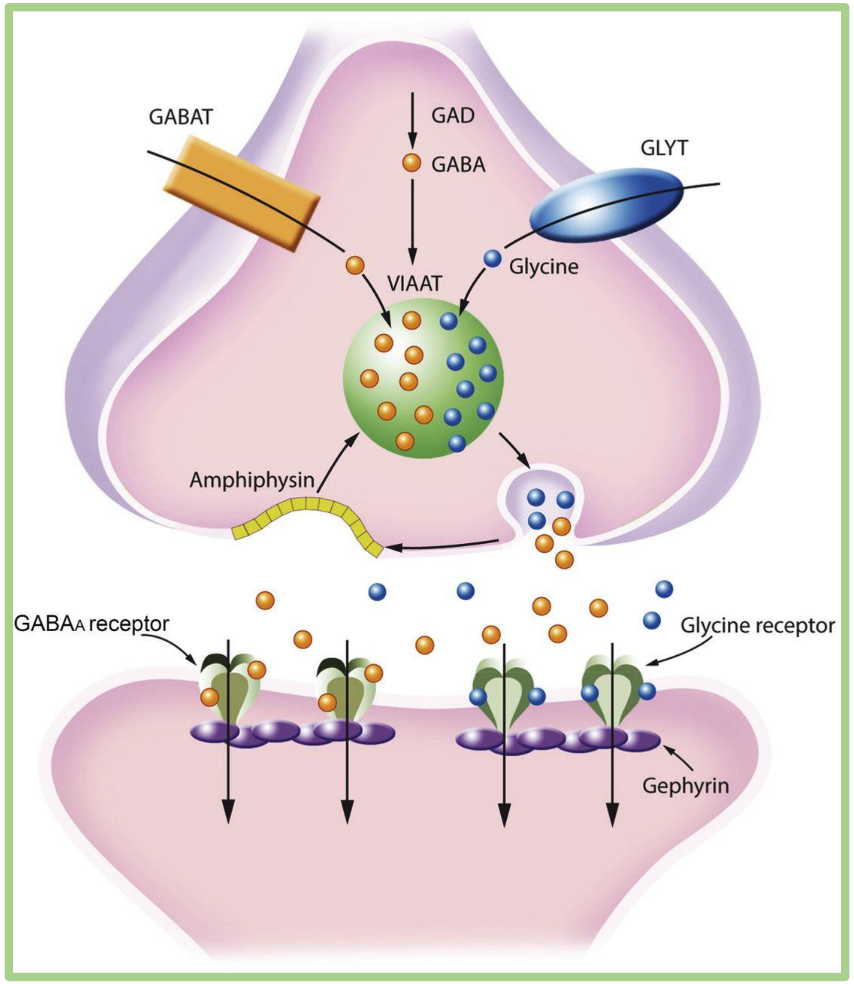
Do Adult-Born and Early Postnatal-Born GCs Exhibit Identical Rate of Spine Turnover?



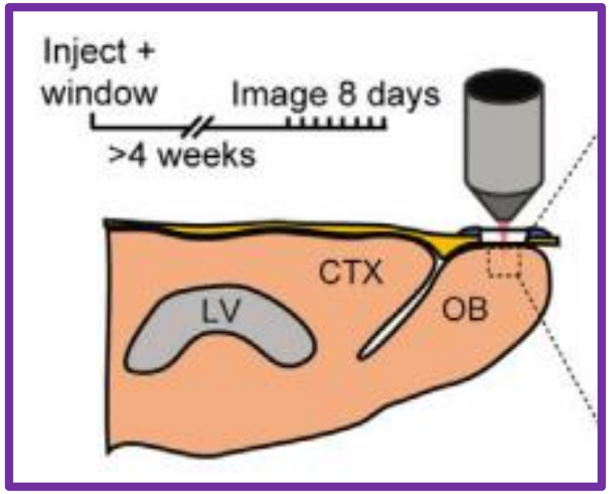
These results suggest that **all GCs** (adult-born **P70** and early postnatal-born **P14**) have ***highly dynamic spines*** throughout life.

High GC spine turnover and MC/TC postsynaptic site:
matching plasticity or competition for fixed synaptic sites?

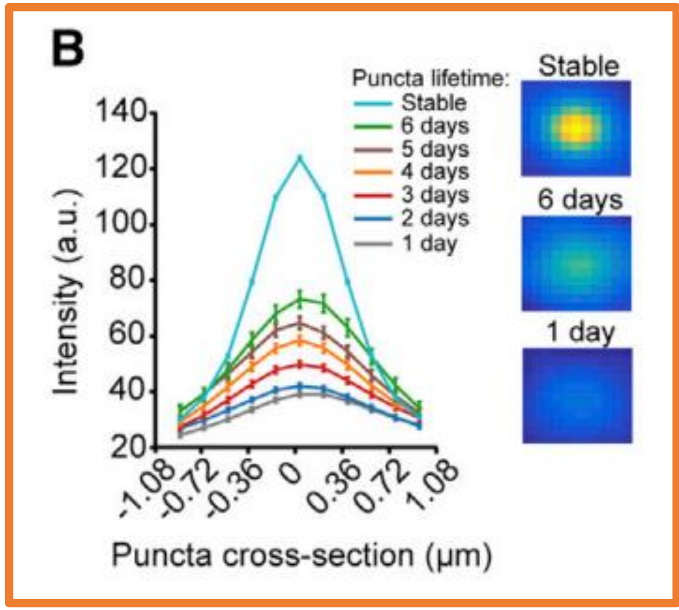




- Lentiviral injection of floxed-teal **gephyrin** into the OB of adult Tbet-Cre mice is performed during the cranial window implantation procedure.
- Imaging begin following a 4-week surgical recovery.



MC/TC Gephyrin Puncta Dynamics Mirror GC Spine Dynamics

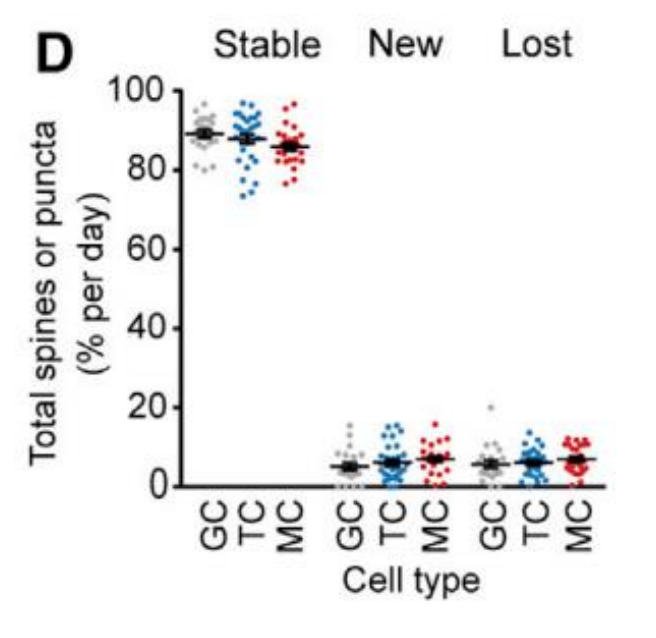


Lost pre-existing puncta are **brighter** than young dynamic fraction puncta

Many **stable long-lived puncta** are subject to ***elimination***

There are **no statistical difference** between the MC/TC ouncta and GC spine dynamic

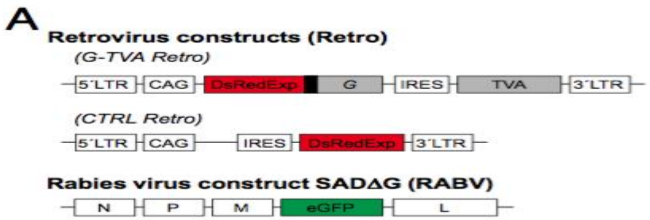
Matched dynamics between the synaptic partners

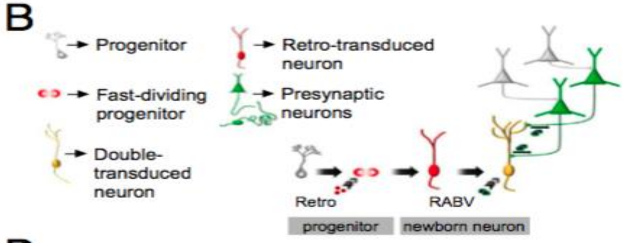


Adult neurogenesis and Adaptation

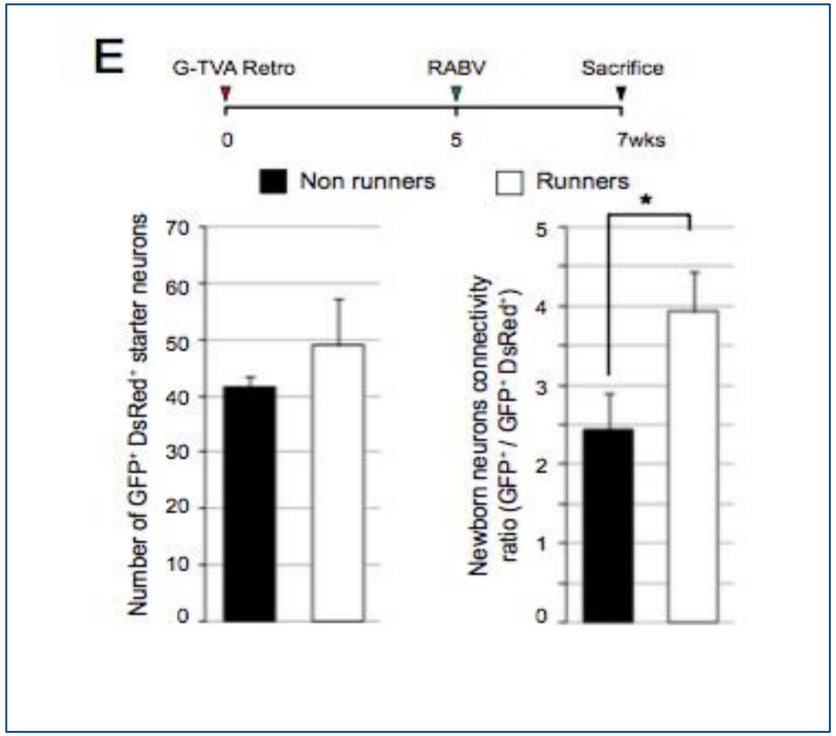
Retrograde monosynaptic tracing reveals the temporal evolution of inputs onto new neurons in the adult dentate gyrus and olfactory bulb

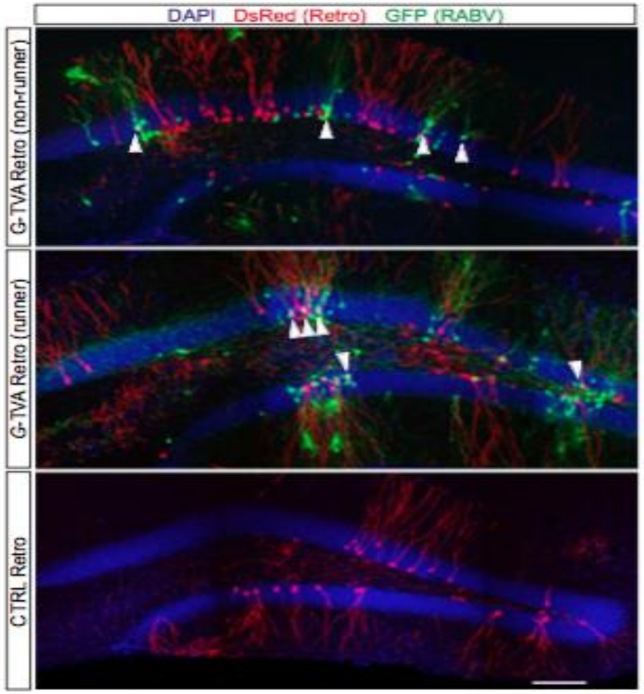
Aditi Deshpande[a,1], Matteo Bergami[a,1], Alexander Ghanem[b], Karl-Klaus Conzelmann[b], Alexandra Lepier[a], Magdalena Götz[a,c,d], and Benedikt Berninger[a,e,f,2]





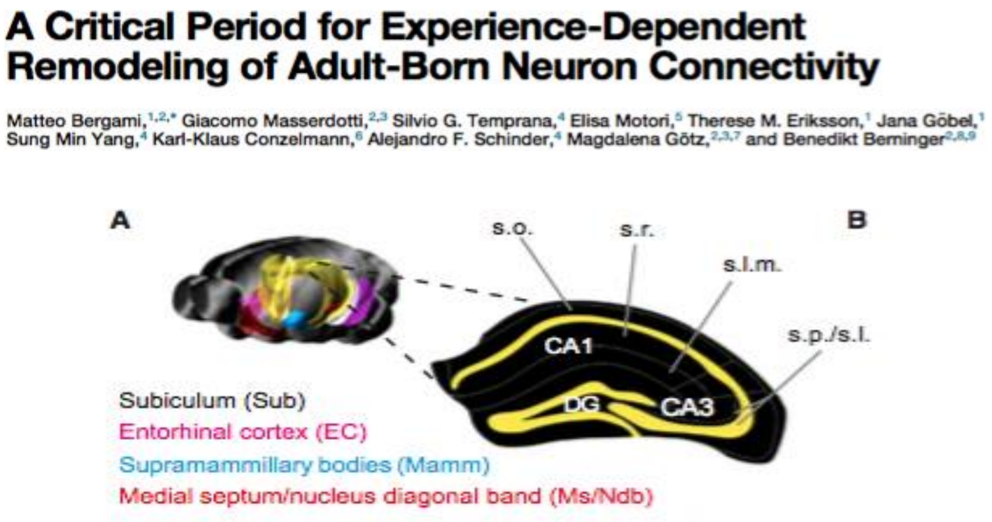
RABV-Based Tracing of Local Presynaptic Partners in the DG

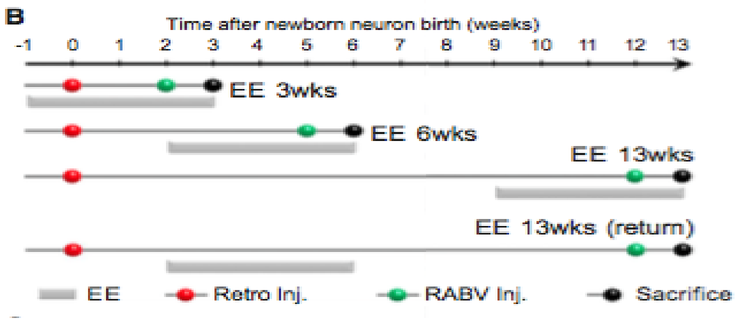


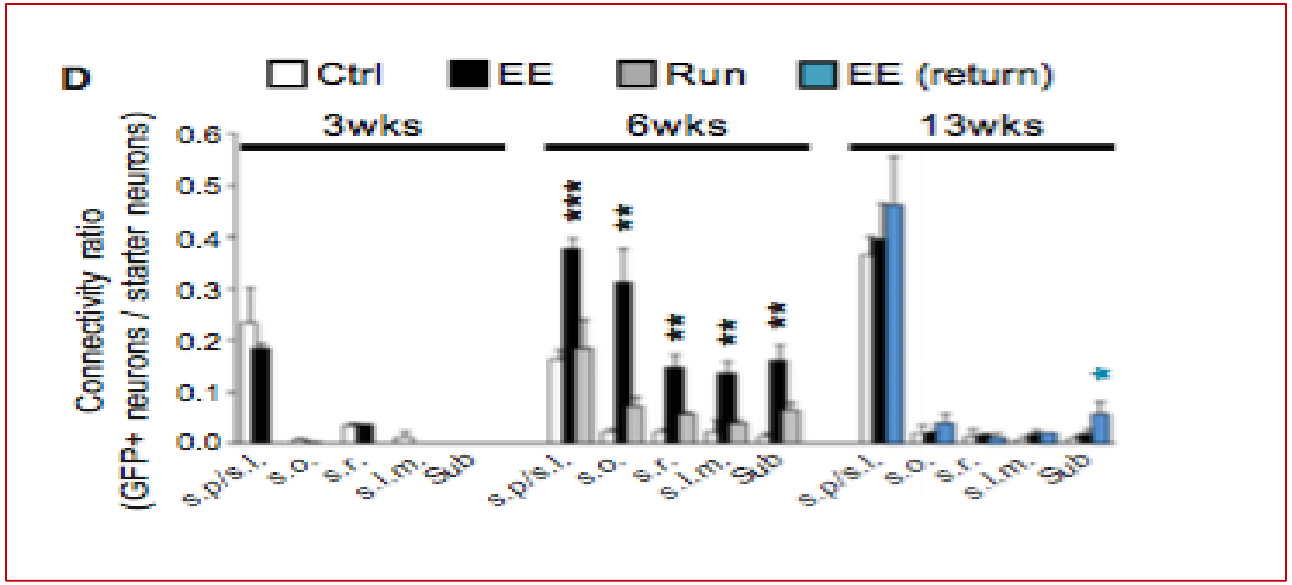


Structural and synaptic plasticity in circuits are directly connected to adult-born neurons.

Adult neurogenesis and Adaptation



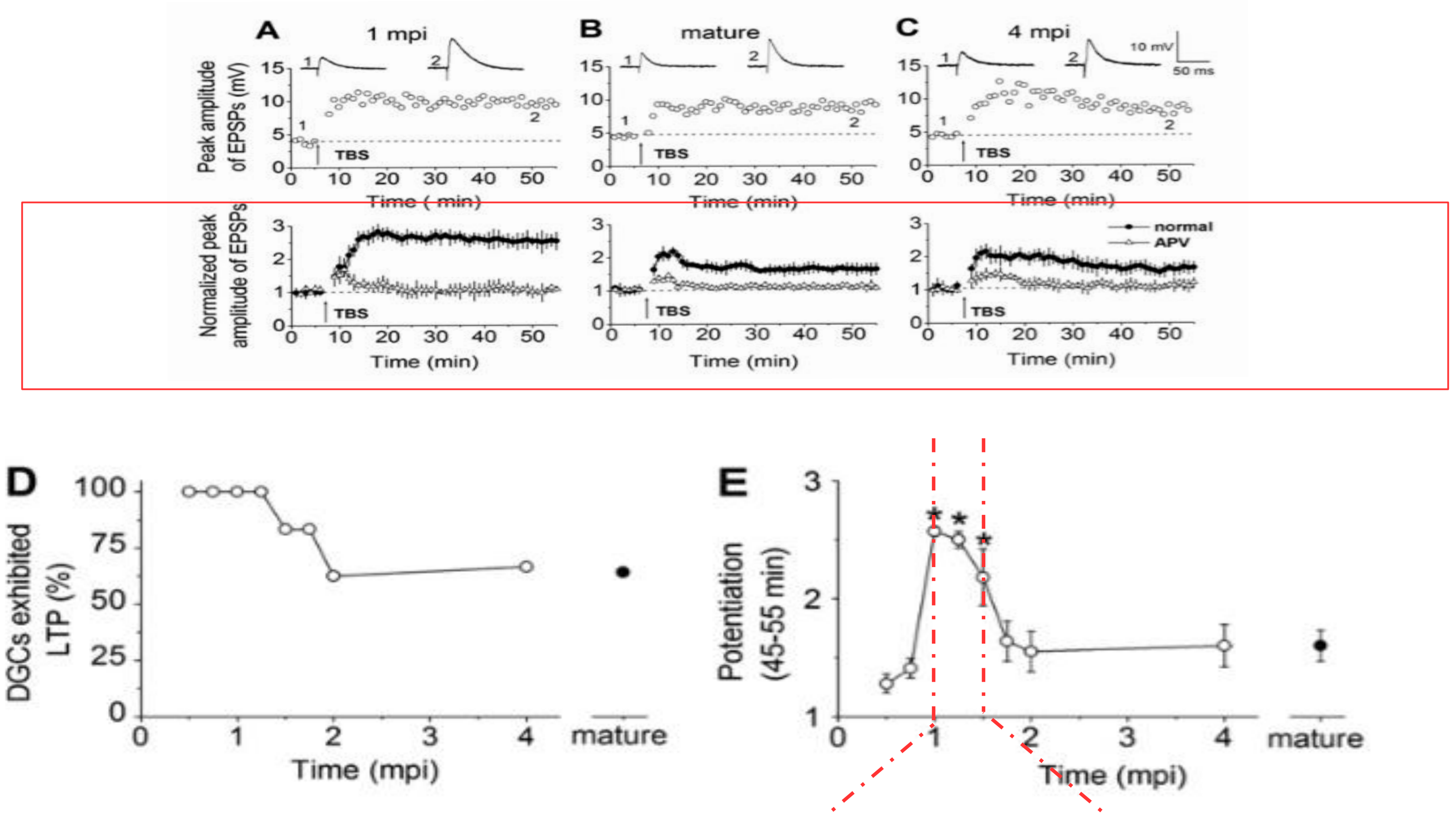




Critical period ?

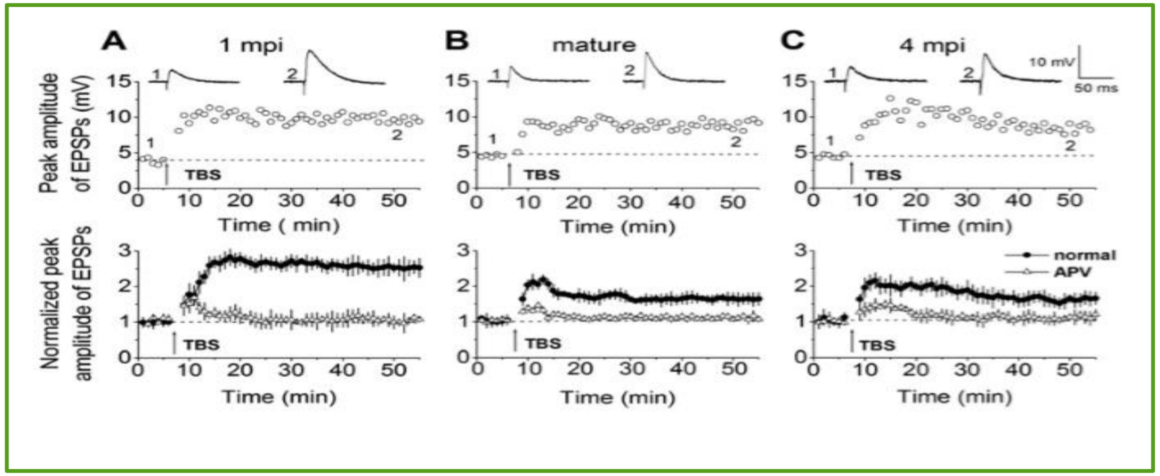
A Critical Period for Enhanced Synaptic Plasticity in Newly Generated Neurons of the Adult Brain

Shaoyu Ge,[1,2,3] Chih-hao Yang,[1,2,4] Kuei-sen Hsu,[4] Guo-li Ming,[1,2,3] and Hongjun Song[1,2,3,*]

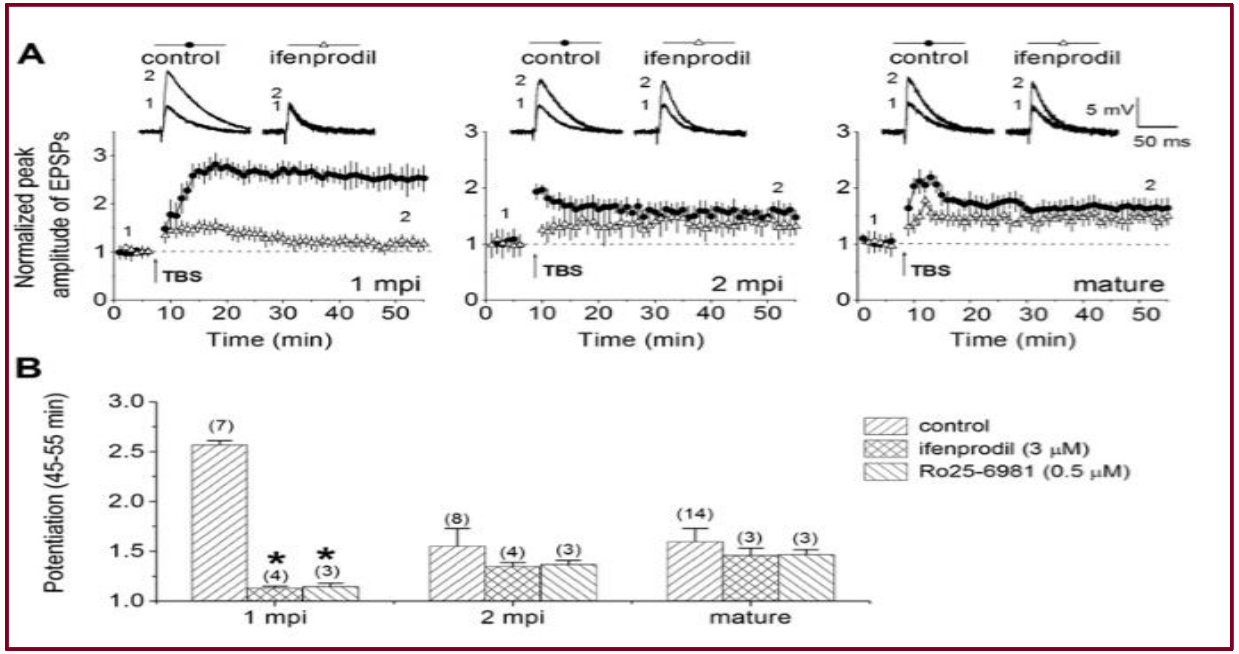


Critical period

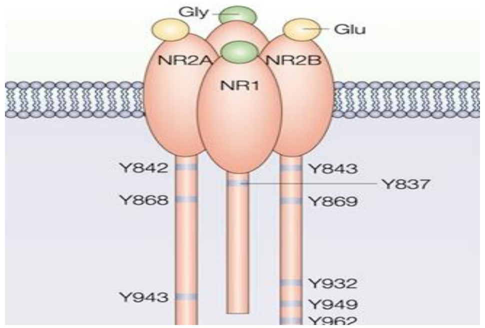
Role of NR2B-Containing NMDARs in the Critical Period Plasticity



Modulation by APV (specific antagonist of NMDARs)



Modulation by Ipenprofil (an NR2B- subtype-specific antagonist)



Subunits of NMDAR

Conclusions and future perspectives

- Synaptic plasticity is the process by which neurogenic regions coordinate pre-existing circuits with the integration of new neurons

- Dendritic spines' turn over sculpt the circuits determining both transient and persistent connections between newborn cells and pre-existing ones

- Synaptic plasticity in adult hippocampus and olfactory bulb is enhanced and potentiated in a critical period and it is an experience and learning-depended process

The influence of neurogenic regions on non-neurogenic connected circuits that could be useful in treatment of diseases through stem cells therapies

The ability of new connections to influence far-damaged circuits can be used to restore the function of the damaged area