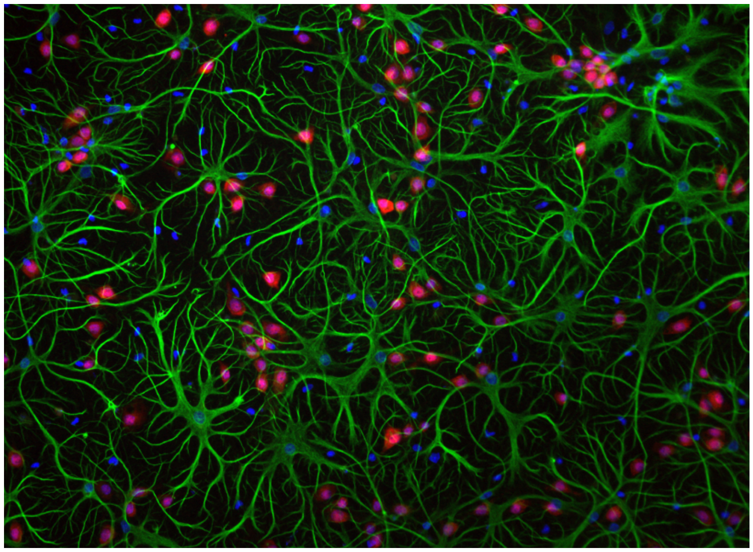


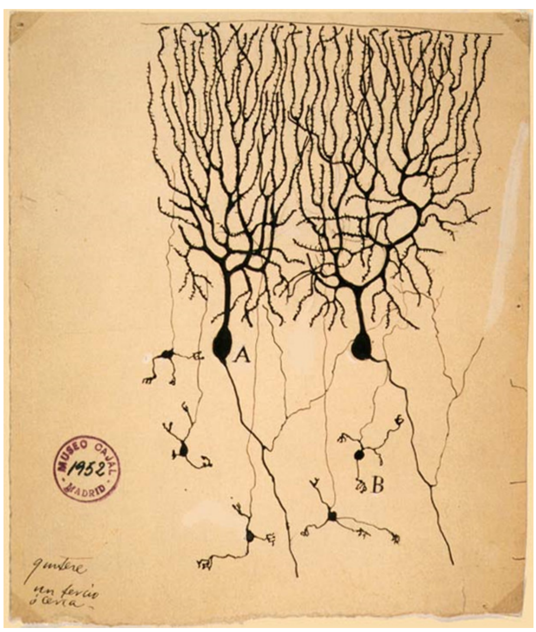
PLASTICITY OF PERFORMANCE

ERIC OETTER

BSMPG 2015 **SUMMER SEMINAR**

Georgia Tech

EMORY UNIVERSITY SCHOOL OF MEDICINE



Fixed.

Ended.

Immutable.

BSMPG 2015 SUMMER SEMINAR

DOIDGE, N. 2007. *THE BRAIN THAT CHANGES ITSELF.* VIKING PENGUIN: NEW YORK

L. Colucci-D'Amato • V. Bonavita • U. di Porzio

The end of the central dogma of neurobiology: stem cells and neurogenesis in adult CNS

Is neuroplasticity in the central nervous system the missing link to our understanding of chronic musculoskeletal disorders?

René Pelletier[1*], Johanne Higgins[1,2] and Daniel Bourbonnais[1,2]

TOPICAL REVIEW

The olympic brain. Does corticospinal plasticity play a role in acquisition of skills required for high-performance sports?

Jens Bo Nielsen[1] and Leonardo G. Cohen[2]

[1]*Department of Exercise and Sport Sciences & Department of Neurobiology and Pharmacology, Panum Institute, University of Copenhagen, Blegdamsvej 3, 2200 Copenhagen N, Denmark*
[2]*Human Cortical Physiology Section and Stroke Neurorehabilitation Clinic, NINDS, Building 10, Room 5 N226, 10 Center Drive MSC 1430, Bethesda, MD 20892-1430, USA*

COLUCCI-D'AMATO L et al. 2006; PELLETIER R et al. 2015; NUDO RJ et al. 1996; NIELSON JB AND COHEN L 2007

Performance is a brain circuit forged through neuroimmune plasticity. #BSMPG2015

Performance is a brain circuit forged through neuroimmune plasticity. #BSMPG2015

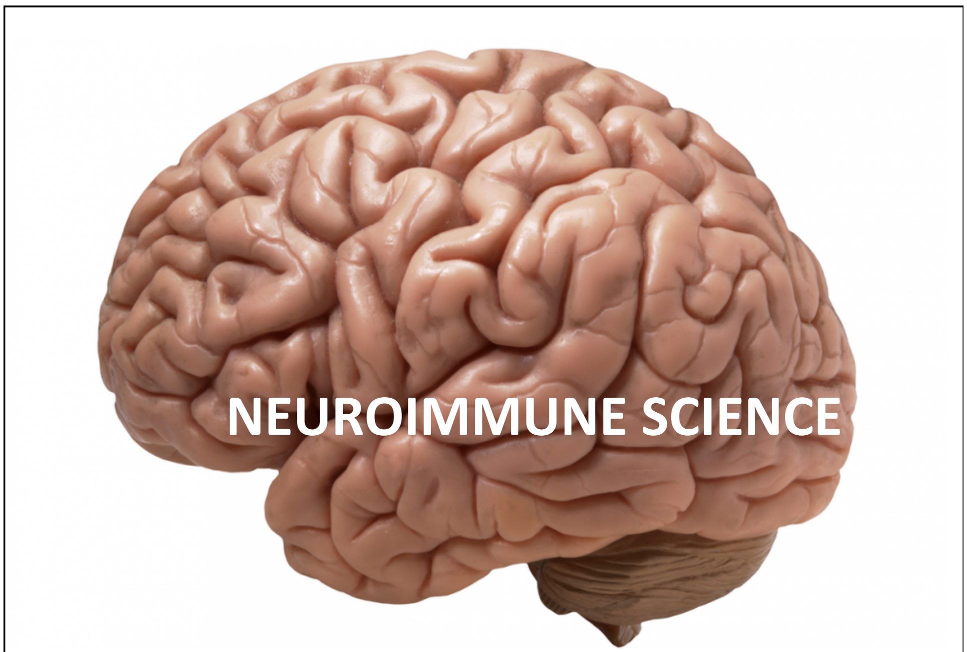
Neuroimmune Science

Neuroimmune Plasticity

#Priming

#Pruning

#Prefrontal



HOW MIGHT THE NEUROIMMUNE SYSTEM WORK?

A suggestion is that it works by being …

complex

self-constructing

distributed

representational

plastic

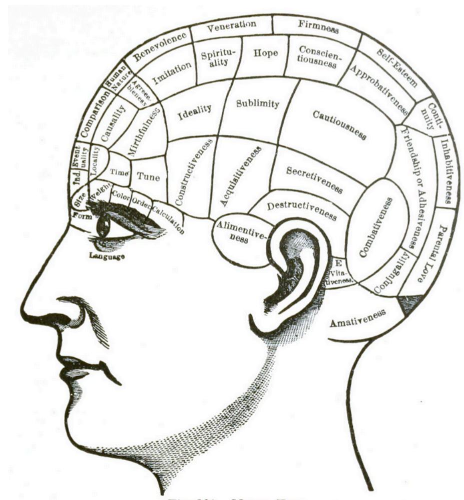
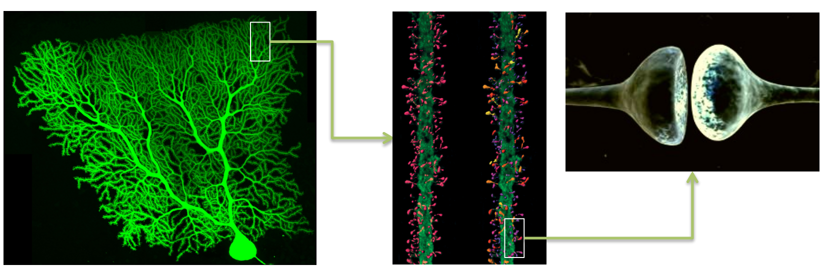
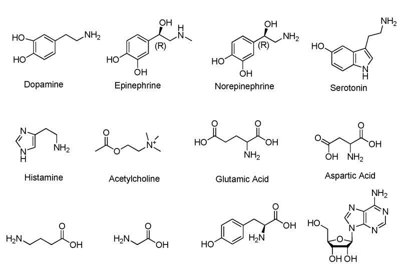


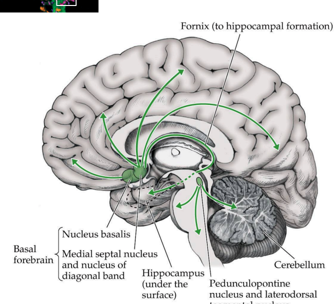
Fig. 264.—Model Head.

BUTLER, D. 2000. *THE SENSITIVE NERVOUS SYSTEM.* NOIGROUP PUBLICATIONS: ADELAIDE CITY WEST

COMPLEXITY – THE HARDWARE & THE WETWARE

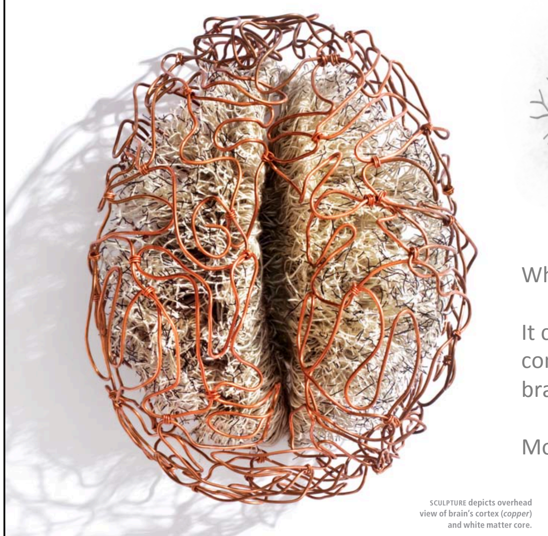




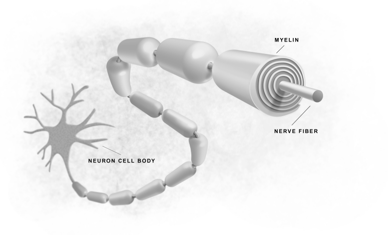


BUTLER, D. 2000. *THE SENSITIVE NERVOUS SYSTEM.* NOIGROUP PUBLICATIONS: ADELAIDE CITY WEST

COMPLEXITY – WHITE MATTER MATTERS



SCULPTURE depicts overhead view of brain's cortex (*copper*) and white matter core.



White matter fills nearly <u>half</u> the brain.

It consists of millions of cables that connect individual neurons from different brain regions.

More myelin = more speed & precision.

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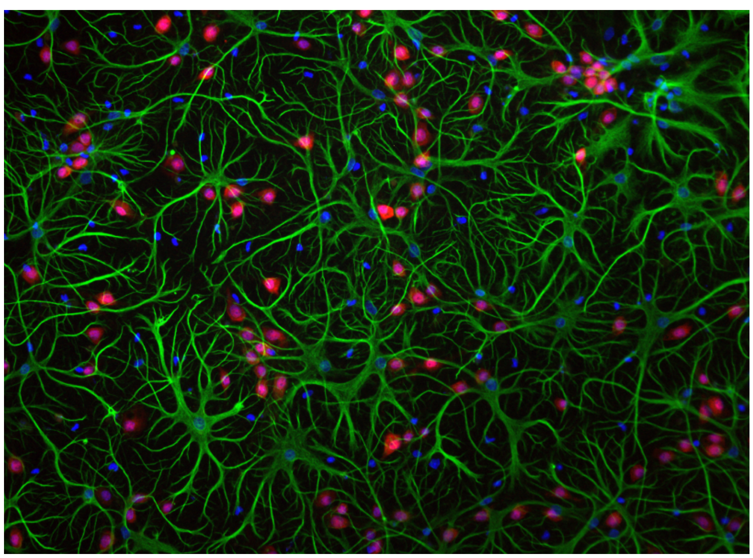
FIELDS, R.D. 2009. *THE OTHER BRAIN.* SIMON & SCHUSTER: NEW YORK

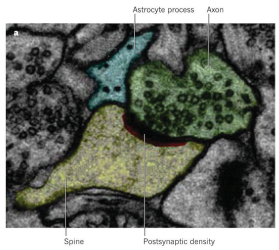
COMPLEXITY – A NEUROIMMUNE ORGAN?

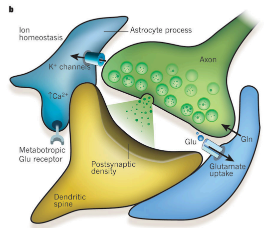


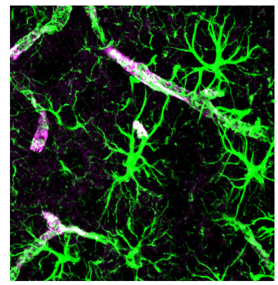
BSMPG 2015 SUMMER SEMINAR

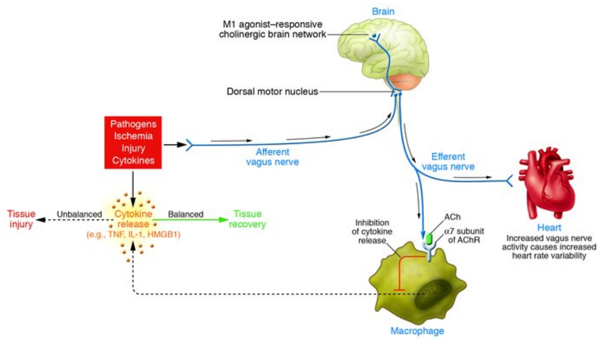
FIELDS, R.D. 2009. *THE OTHER BRAIN.* SIMON & SCHUSTER: NEW YORK

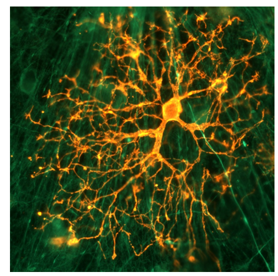
COMPLEXITY – A NEUROIMMUNE ORGAN?











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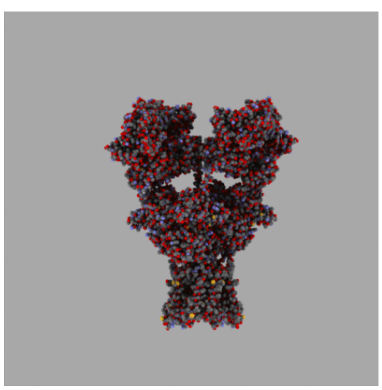
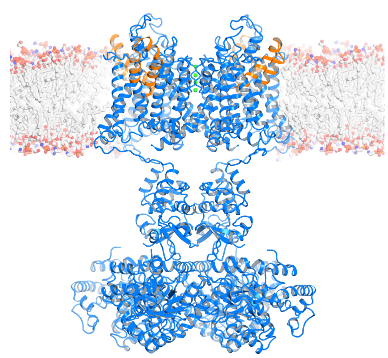
FIELDS, R.D. 2009. *THE OTHER BRAIN.* SIMON & SCHUSTER: NEW YORK

ION CHANNELS – THE HARDWARE/WETWARE INTERFACE

The molecular substrate for a ***self-constructing*** distributed representational system.





Signal → DNA —Transcription→ mRNA —Translation→ Protein "workhorses"

Ion channels are the molecular targets of manual and movement therapies. ***Said simply, they reflect the "need" of the individual.***

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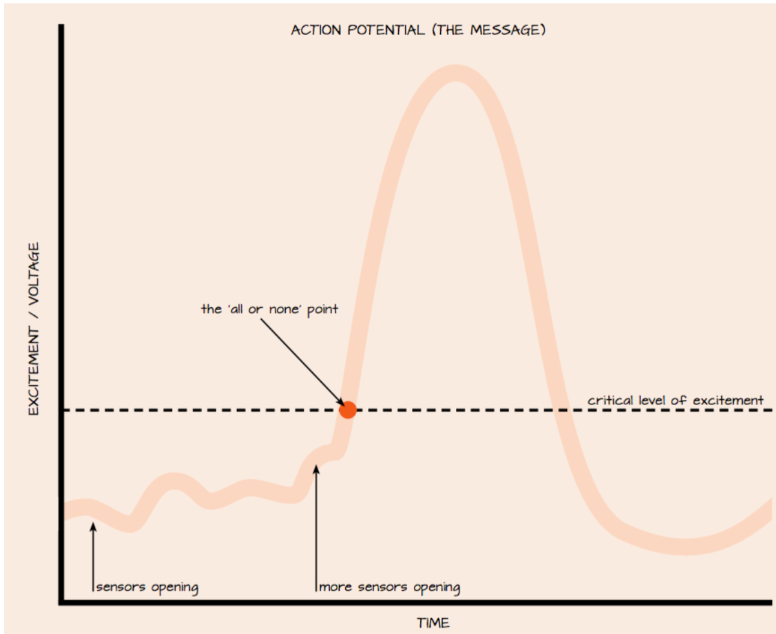
BUTLER, D. 2000. *THE SENSITIVE NERVOUS SYSTEM.* NOIGROUP PUBLICATIONS: ADELAIDE CITY WEST



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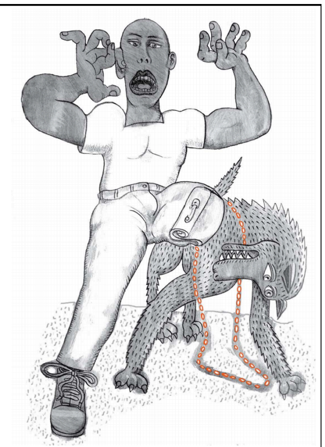
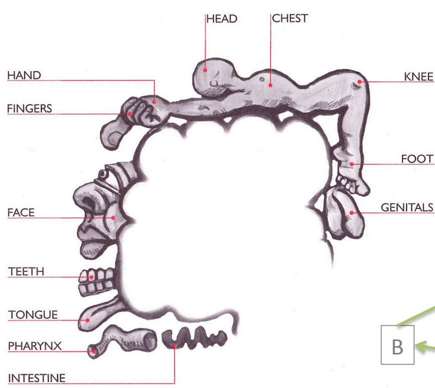
BUTLER, D & MOSELEY, L. 2013. *EXPLAIN PAIN.*
NOIGROUP PUBLICATIONS: ADELAIDE CITY WEST

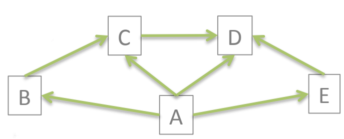
THE NEUROMATRIX PARADIGM

What are all these neurons and glial cells for?

Representation within the "coding space" of the brain.







These neuro-representations (or "neurotags") are ***distributed***, parallel and bilateral.

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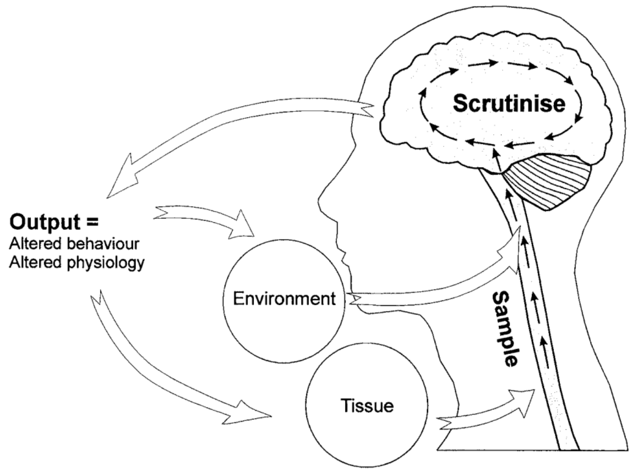
BUTLER, D & MOSELEY, L. 2013. *EXPLAIN PAIN.*
NOIGROUP PUBLICATIONS: ADELAIDE CITY WEST

THE NEUROMATRIX PARADIGM



Outputs depend on the value the CNS gives the input. The brain weighs the world and decides whether a response (e.g. pain, motor, sweat) should be constructed.

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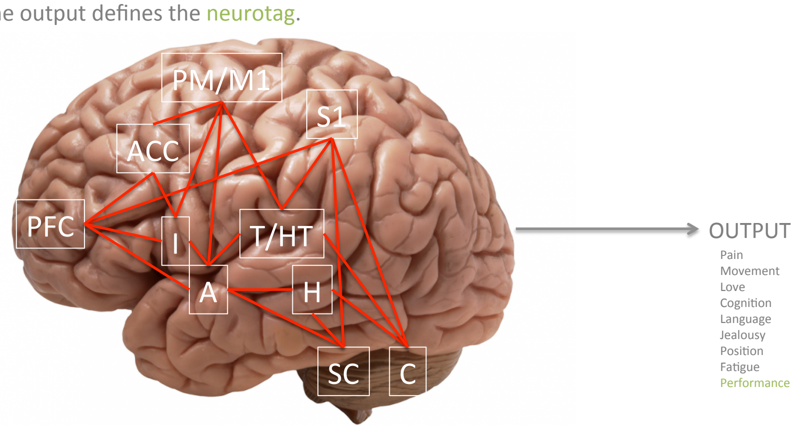
GIFFORD, LS. 1998. PAIN, THE TISSUES AND THE NERVOUS SYSTEM. *PHYSIOTHERAPY* 84: 27-33

NEUROTAGS – THE EVENT SPACE

A neurotag is a pattern of activity within the neuromatrix.

When a neurotag is activated, it produces an output (an experience or action).

The output defines the neurotag.



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MOSELEY, L et al. 2012. THE *GRADED MOTOR IMAGERY HANDBOOK.* NOIGROUP PUBLICATIONS: ADELAIDE CITY WEST

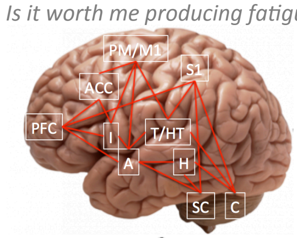
DECONSTRUCTING THE FATIGUE NEURTAG

Is it worth me producing fatigue?

"ISSUES IN THE TISSUES"

- [H+]
- [P_i]
- PaO_2
- Ergoception (III/IV)
- Nociception
- Temperature
- Blood volume

"DANGER" NEUROTAG (-)



"DANGER" NEUROTAG (-)

PSYCHOSOCIAL

- Beliefs
- Logic
- Knowledge
- Previous exposure
- Social context
- Culture
- Expectation

MODULATES — Energy Systems Development

Graded Exposure
ANS Balance
Deception — MODULATES

(-) FATIGUE → CONCERTED BEHAVIORAL RESPONSE TO PROTECT HOMEOSTASIS

What matters to the brain is context.

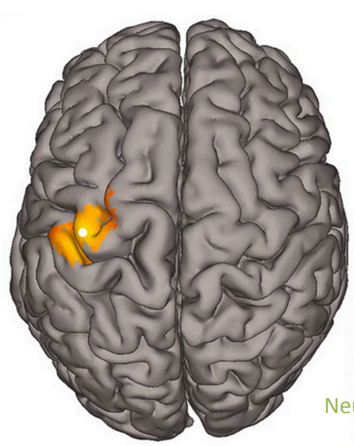
BSMPG 2015 SUMMER SEMINAR

NOAKES, T. 2012. FATIGUE IS A BRAIN-DERIVED EMOTION THAT REGULATES THE EXERCISE BEHAVIOR TO ENSURE WHOLE BODY HOMEOSTASIS. *FRONT. PHYSIO.* 3:82

NEUROTAGS – THE EVENT SPACE

Two critically important criteria …

1. The member brain cells have to fire.
2. Nearby brain cells have to NOT fire.



Neurotags will alter their landscape to look after you.

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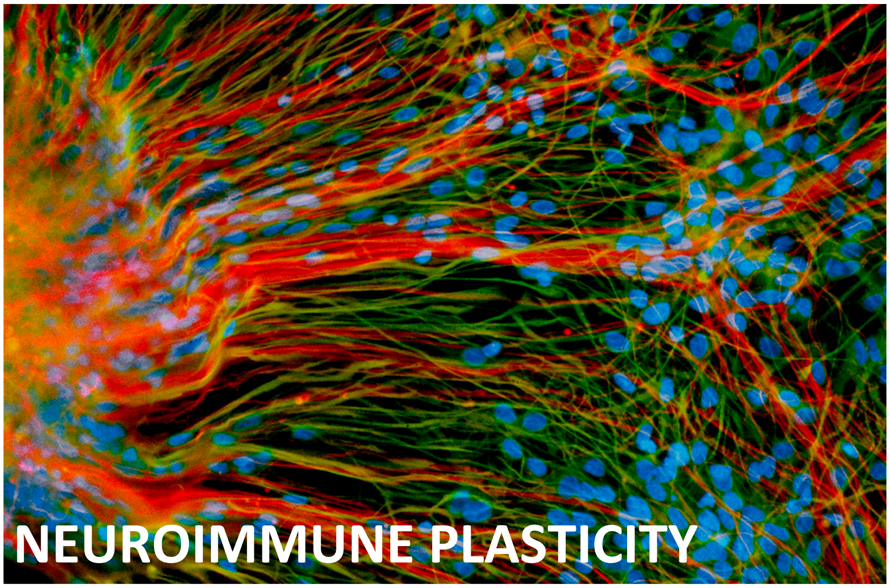
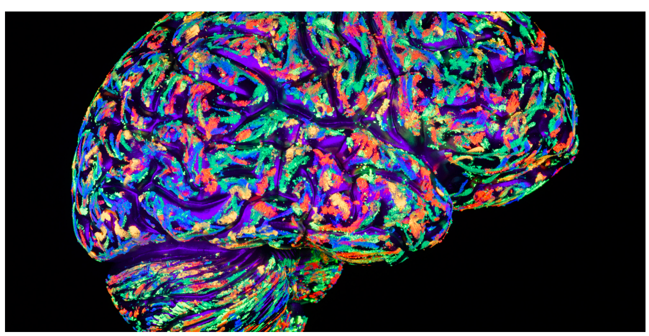
MOSELEY, L et al. 2012. THE *GRADED MOTOR IMAGERY HANDBOOK.* NOIGROUP PUBLICATIONS: ADELAIDE CITY WEST



PLASTICITY IN THE CNS

Neuroplasticity means a change in function of a neuron or group of neurons. These changes are use-dependent.



[plas-tik]

All learning is represented by structural and functional changes to all levels of the neuroimmune system.

BUTLER, D. 2000. *THE SENSITIVE NERVOUS SYSTEM.* NOIGROUP PUBLICATIONS: ADELAIDE CITY WEST

NEUROTAGS ARE DYNAMICALLY MAINTAINED

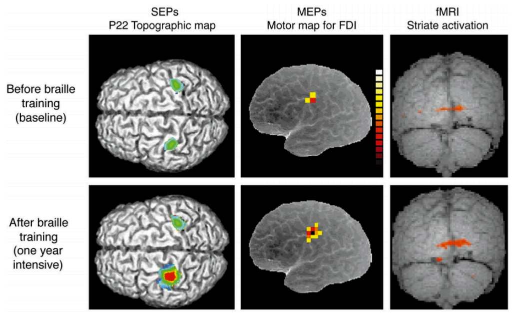
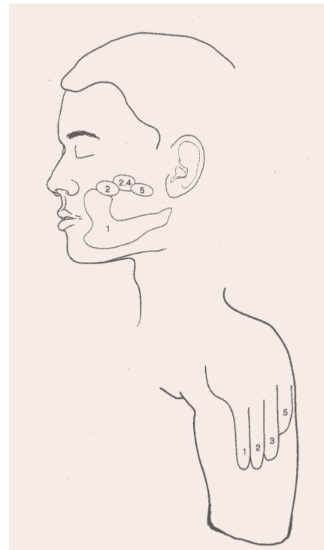


Fig. 1 Evidence of plasticity in sensory, motor and occipital cortex in early-blind subjects after learning Braille. Representative examples are shown from the studies performed before (top) and at the end of one year of learning Braille (bottom). The different studies were conducted on different subjects using somatosensory evoked potentials (SEPs) to mechanical stimuli to the index finger pad, motor mapping with TMS of the potentials evoked in the first dorsal interosseus (FDI) muscle (the side-to-side mover of the index finger), and functional magnetic resonance imaging (fMRI) while reading Braille characters. (Adapted from Refs 13,18.)

Thomas Elbert · Annette Sterr · Herta Flor
Brigitte Rockstroh · Stefan Knecht · Christo Pantev
Christian Wienbruch · Edward Taub

Input-increase and input-decrease types of cortical reorganization after upper extremity amputation in humans



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PASCUAL-LEONE A AND TORRES F 1993; ELBERT T et al. 1997; RAMACHANDRAN VS AND BLAKESLEE S 1998

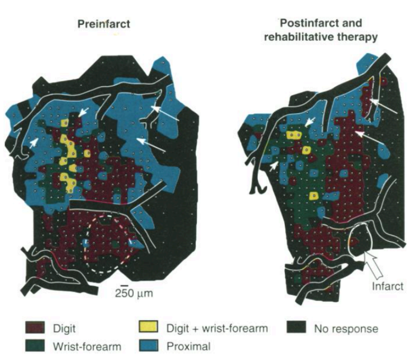
A VARIETY OF INPUTS CAN ALTER NEUROTAGS

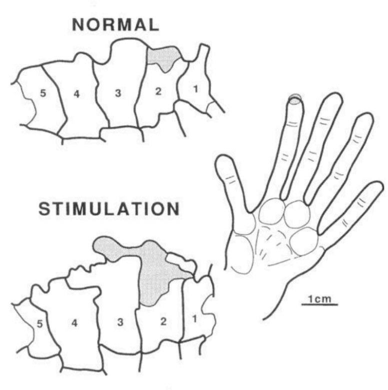
Activation of the primary visual cortex by Braille reading in blind subjects

Norihiro Sadato*†, Alvaro Pascual-Leone*, Jordan Grafman‡, Vicente Ibañez*, Marie-Pierre Deiber*, George Dold§ & Mark Hallett*

Increased Cortical Representation of the Fingers of the Left Hand in String Players

Thomas Elbert, Christo Pantev, Christian Wienbruch, Brigitte Rockstroh, Edward Taub





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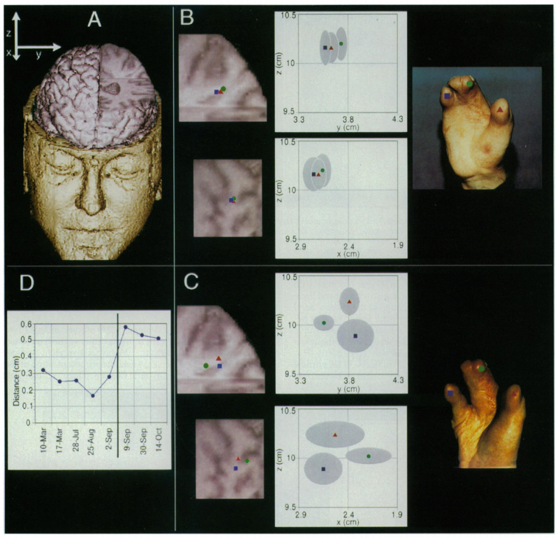
SADATO, N. et al. 1996; ELBERT, T. et al. 1995; NUDO RJ et al. 1996; JENKINS WM, MERZENICH MM, OCHS MT et al 1990

NEUROTAG REORGANIZATION HAPPENS QUICKLY



Cerebral Cortex September 2007;17:2134-2142
doi:10.1093/cercor/bhl120
Advance Access publication November 16, 2006

Temporal Dynamics of Plastic Changes in Human Primary Somatosensory Cortex after Finger Webbing

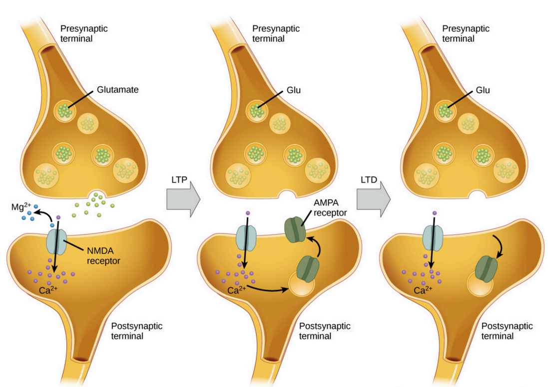
The primary somatosensory cortex (SI) exhibits a detailed topographic organization of the hand and fingers, which has been found to undergo plastic changes following modifications of the sensory input. Although the spatial properties of these changes have been extensively investigated, little is known about their temporal dynamics. In this study, we adapted the paradigm of finger webbing, in which 4 fingers are temporarily webbed together, hence modifying their sensory feedback. We used magnetoencephalography, to measure changes in the hand representation in SI, before, during, and after finger webbing for about 5 h. Our results showed a decrease in the Euclidean distance (ED) between cortical sources activated by electrical stimuli to the index and small finger 30 min after webbing, followed by an increase lasting for about 2 h after webbing, which was followed by a return toward baseline values. These results provide a unique frame in which the different representational changes occur, merging previous findings that were only apparently controversial, in which either increases or decreases in ED were reported after sensory manipulation for relatively long or short duration, respectively. Moreover, these observations further confirm that the mechanisms that underlie cortical reorganization are extremely rapid in their expression and, for the first time, show how brain reorganization occurs over time.

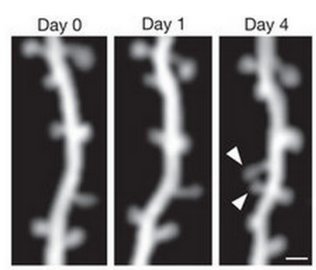
MOLINGER A et al. 1993; STAVRINOU M et al. 2006

GREY MATTER PLASTICITY

"Neurons that fire together, wire together."

Long-term potentiation requires cooperativity, associativity, and specificity.



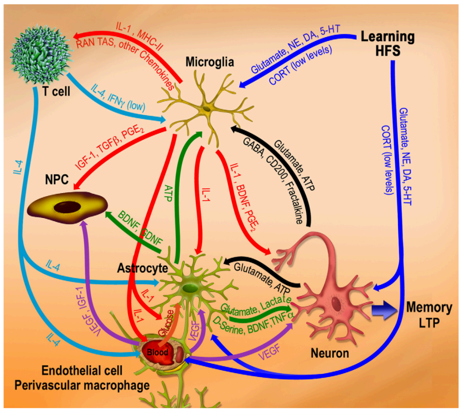


BUTLER, D. 2000. *THE SENSITIVE NERVOUS SYSTEM.* NOIGROUP PUBLICATIONS: ADELAIDE CITY WEST

Immune modulation of learning, memory, neural plasticity and neurogenesis

Raz Yirmiya *, Inbal Goshen

Department of Psychology, The Hebrew University of Jerusalem, Jerusalem 91905, Israel

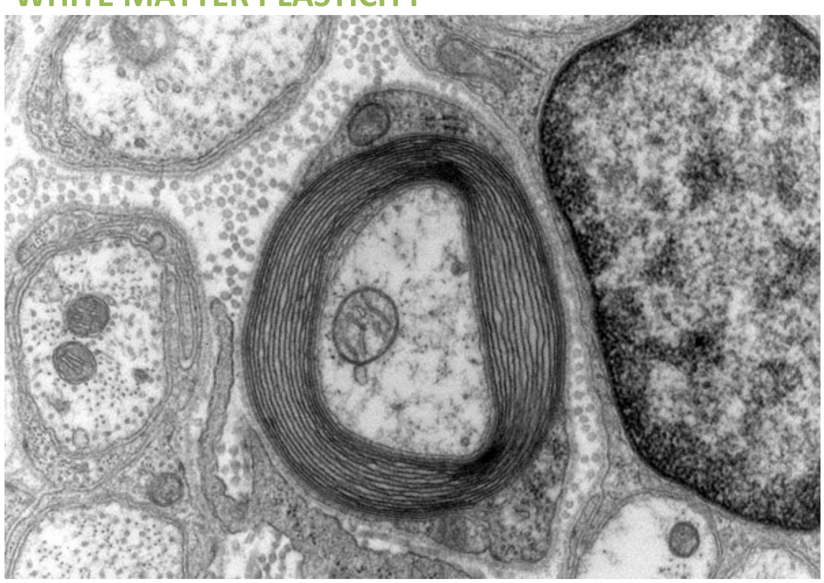


A B S T R A C T

Over the past two decades it became evident that the immune system plays a central role in modulating learning, memory and neural plasticity. Under normal quiescent conditions, immune mechanisms are activated by environmental/psychological stimuli and positively regulate the remodeling of neural circuits, promoting memory consolidation, hippocampal long-term potentiation (LTP) and neurogenesis. These beneficial effects of the immune system are mediated by complex interactions among brain cells with immune functions (particularly microglia and astrocytes), peripheral immune cells (particularly T cells and macrophages), neurons, and neural precursor cells. These interactions involve the responsiveness of non-neuronal cells to classical neurotransmitters (e.g., glutamate and monoamines) and hormones (e.g., glucocorticoids), as well as the secretion and responsiveness of neurons and glia to low levels of inflammatory cytokines, such as interleukin (IL)-1, IL-6, and TNFα, as well as other mediators, such as prostaglandins and neurotrophins. In conditions under which the immune system is strongly activated by infection or injury, as well as by severe or chronic stressful conditions, glia and other brain immune cells change their morphology and functioning and secrete high levels of pro-inflammatory cytokines and prostaglandins. The production of these inflammatory mediators disrupts the delicate balance needed for the neurophysiological actions of immune processes and produces direct detrimental effects on memory, neural plasticity and neurogenesis. These effects are mediated by inflammation-induced neuronal hyper-excitability and adrenocortical stimulation, followed by reduced production of neurotrophins and other plasticity-related molecules, facilitating many forms of neuropathology associated with normal aging as well as neurodegenerative and neuropsychiatric diseases.

YIRMIYA, R AND GOSHEN, I. 2011.IMMUNE MODULATION OF LEARNING, MEMORY, NEURAL PLASTICITY, AND NEUROGENESIS. *BRAIN, BEHAVIOR, AND IMMUNITY* 25:181-213

WHITE MATTER PLASTICITY



FIELDS, R.D. 2009. *THE OTHER BRAIN.* SIMON & SCHUSTER: NEW YORK

Performance is a brain circuit forged through neuroimmune plasticity. #BSMPG2015

Nat Neurosci. 2005 Sep;8(9):1148-50. Epub 2005 Aug 7.

Extensive piano practicing has regionally specific effects on white matter development.

Bengtsson SL[1], Nagy Z, Skare S, Forsman L, Forssberg H, Ullén F.

Neuron. 2000 Feb;25(2):493-500.

Microstructure of temporo-parietal white matter as a basis for reading ability: evidence from diffusion tensor magnetic resonance imaging.

Klingberg T[1], Hedehus M, Temple E, Salz T, Gabrieli JD, Moseley ME, Poldrack RA.

Biol Psychol. 2000 Oct;54(1-3):241-57.

Structural and functional brain development and its relation to cognitive development.

Casey BJ[1], Giedd JN, Thomas KM.

Neuropsychologia. 2007 Jun 11;45(10):2277-84. Epub 2007 Mar 4.

White matter volume predicts reaction time instability.

Walhovd KB[1], Fjell AM.

Hum Brain Mapp. 2005 Oct;26(2):139-47.

Cognitive functions correlate with white matter architecture in a normal pediatric population: a diffusion tensor MRI study.

Schmithorst VJ[1], Wilke M, Dardzinski BJ, Holland SK.

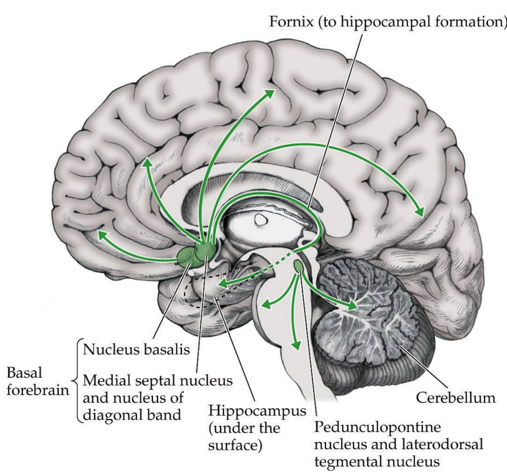
Neuropsychologia. 2007 Jun 18;45(11):2439-46. Epub 2007 Apr 19.

Speed of lexical decision correlates with diffusion anisotropy in left parietal and frontal white matter: evidence from diffusion tensor imaging.

Gold BT[1], Powell DK, Xuan L, Jiang Y, Hardy PA.

FIELDS, R.D. 2009. *THE OTHER BRAIN.* SIMON & SCHUSTER: NEW YORK

PRINCIPLES OF NEUROIMMUNE PLASTICITY



Principles of Experience-Dependent Neural Plasticity: Implications for Rehabilitation After Brain Damage

SUPPLEMENT

- Use it or lose it.
- Use it and improve it.
- Specificity.
- Repetition.
- Intensity.
- Time.
- Salience.
- Age.
- Transference.
- Interference.

KLEIM JA AND JONES TA. 2008. PRINCIPLES OF EXPERIENCE-DEPENDENT NEURAL PLASTICITY: IMPLICATIONS FOR REHABILITATION AFTER BRAIN DAMAGE. *J SPEECH LANG HEAR RES.* 51(1): S225-39


#PRIMING