

Neurotechnology

Intelligent robotics

Health Robotics

Assistive robotics

Replacing robotics (e.g. prosthesis)

Rehabilitation robotics

Neurotechnology

Physiologically connected robotics

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MÄLARDALENS HÖGSKOLA
ESKILSTUNA VÄSTERÅS

Some presentations

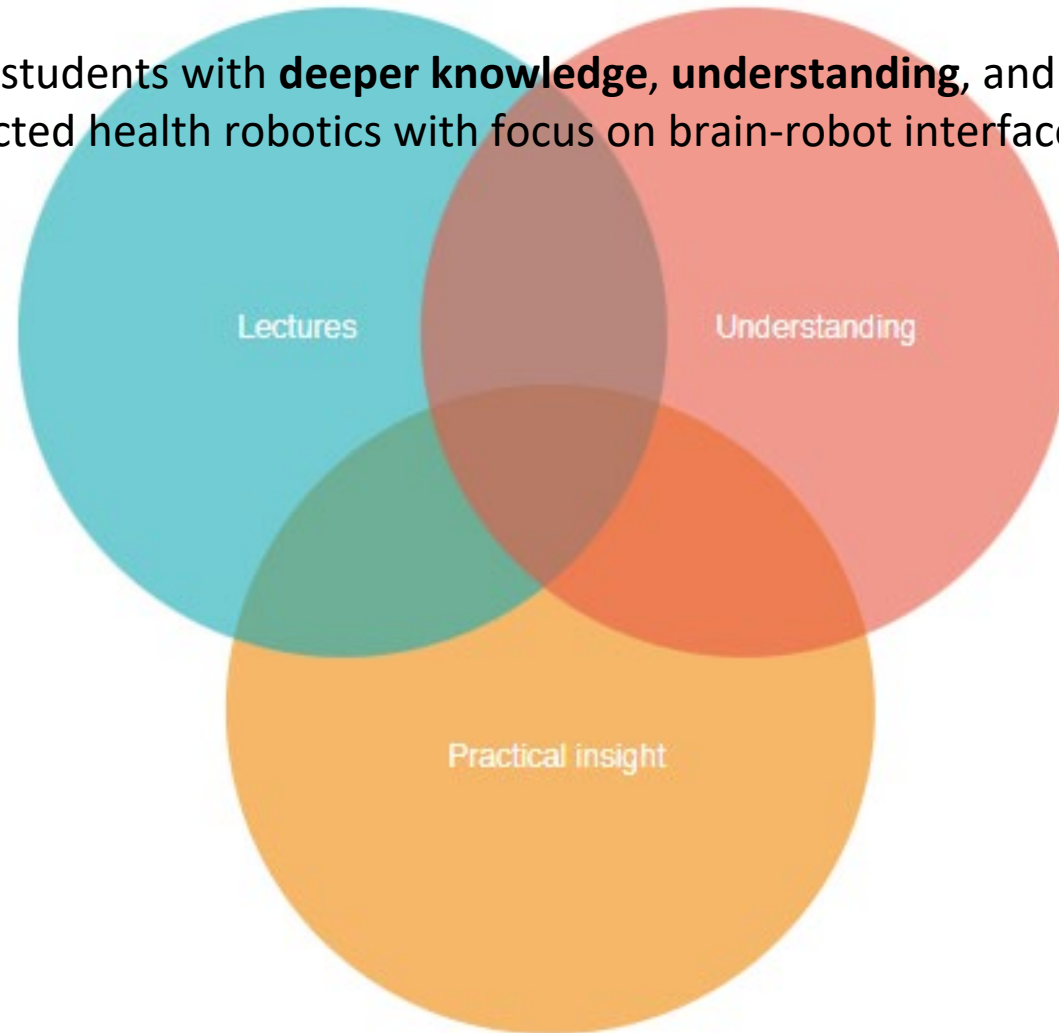
- Martin Johansson
- Joana Silva
- Elmeri Syrjänen

Goals for Neurotechnology

- “The purpose of the course is to provide students with deeper knowledge, understanding, and practical insight in physiologically connected health robotics with focus on brain-robot interfaces.”
 1. Have insight and be able to critically review frontier research within different applicative areas of health robotics,
 2. Show an understanding of critical parameters of interfaces both in terms of physiological signal and control signal to robot and also
 3. Show in-depth knowledge within a chosen application of health robotics, be able to practically implement and describe its function.

Goals for Neurotechnology

- “The purpose of the course is to provide students with **deeper knowledge, understanding, and practical insight** in physiologically connected health robotics with focus on brain-robot interfaces.”
 - **deeper knowledge** = Lectures
 - **understanding** = Seminars
 - **practical insight** = Project



Goals for Neurotechnology

- Learning outcomes
 1. Have insight and be able to critically review frontier research within different applicative areas of health robotics,
 - Lecture 3 (this one)
 - Seminar 1

Goals for Neurotechnology

- Learning outcomes
 - 2. Show an understanding of critical parameters of interfaces both in terms of physiological signal and control signal to robot
- Project labs, Project meetings, seminar 2 and 3, Lecture 1

Goals for Neurotechnology

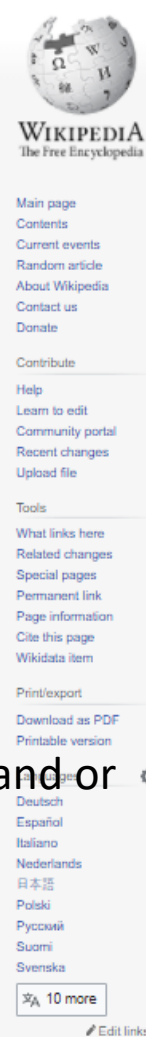
- Learning outcomes
 - 3 Show in-depth knowledge within a chosen application of health robotics, be able to practically implement and describe its function.
- Project development, Demonstration and Report, Lecture 2

Lecture 3

- Brain-Machine Interfaces (BMIs)
- Real-time pattern recognition
- Closed loop brain training
- ... (and some terminology)

Closed loop brain

- Terminology
- Specific Scientific meaning
- Wikipedia
- Authors definition
- May still be difficult to understand or implement



Article Talk

Coherence

From Wikipedia, the free encyclopedia

Coherence

A measure of how stable the frequency and/or phase relationship is between two neural sites; it reflects the amount of information that is shared between two sensors or channels.

(spatially constant) interference for a chosen set of base units, is a product of powers of base units with no other proportionality factor than one
) may be considered coherent; the time interval within which its phase is, on average, predictable

two signals or data sets
length of association between two series
positions of elementary morphisms are equal

ows one to extend an isometry from the degree-zero subspace of a space of characters to the whole space
sly linked to the geometrical properties of the underlying space
lute value of the cross-correlations between the columns of a matrix
etric introduced by Yang et al., 2016

The correlated activation of two neural substrates is termed 'functional connectivity' in haemodynamic modalities and 'coherence' in electrophysiological terms.

- Coherence (programming language), an
- Cache coherence, a special case of me
- Memory coherence, a concept in compi

IT products

- Coherence (software), a component of Parallels Desktop for Mac, the Windows virtualization software

Sitaram et al. 2017 (p.87)

Other uses

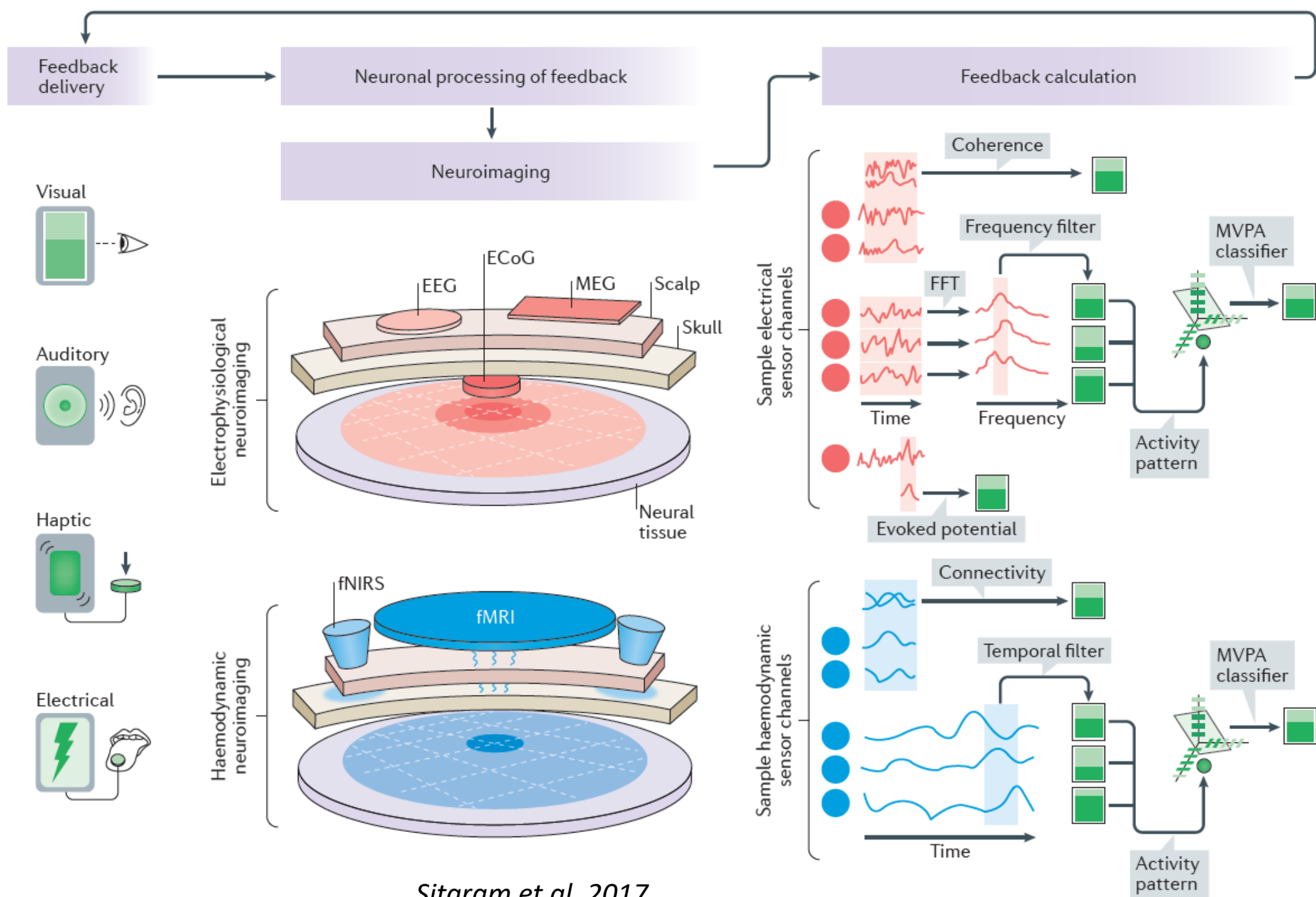
- Coherence (cognitive science), a property of mental/cognitive states
- Coherence (linguistics), what makes a text semantically meaningful
- Coherence (music theory), a synonym for strict Rottenberg propriety in diatonic set theory
- Coherent optical module, a hot-pluggable optical transceiver implementing a coherent modulation algorithm
- Coherence time (communications systems), duration when a communication channel can be assumed to be constant
- Coherent, Inc., a company specializing in equipment to make and measure coherent light (lasers)
- Coherent risk measure in financial economics, a function that satisfies properties of monotonicity, sub-additivity, homogeneity, and translational invariance
- *Coherence* (film), a 2013 science fiction film by James Ward Byrkit
- Sense of coherence, a construct in the health theory salutogenesis

See also

- Cohesion (disambiguation)
- Mutual coherence (disambiguation)
- All pages with titles beginning with coherence
- All pages with titles beginning with coherent

Closed loop brain training

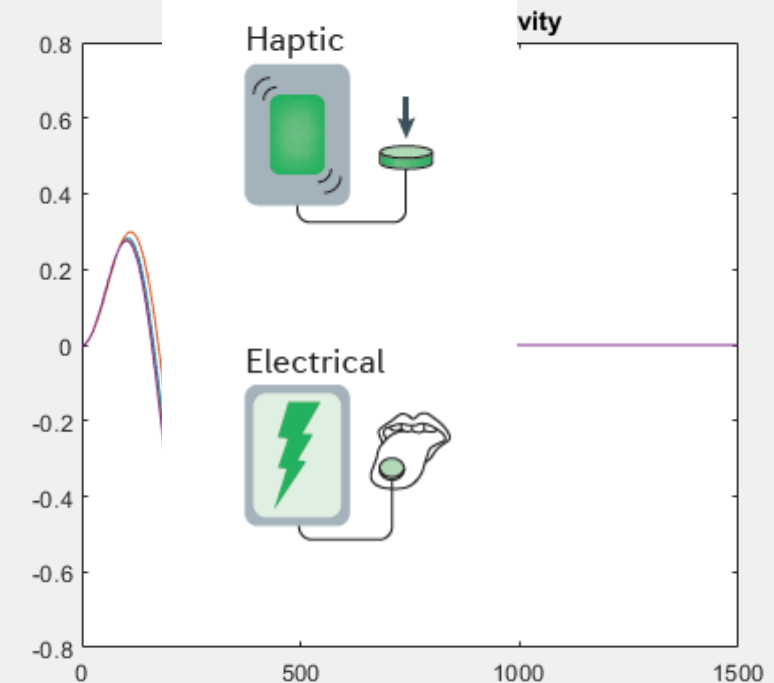
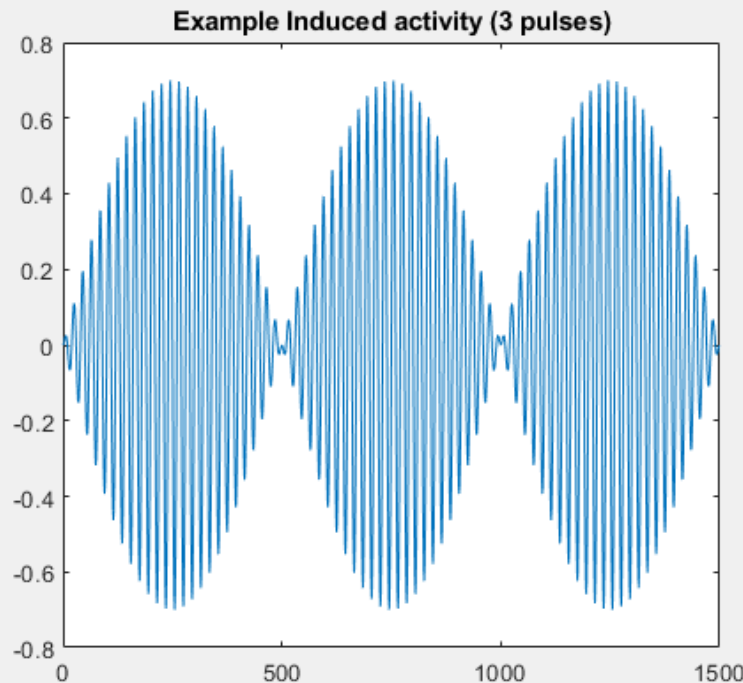
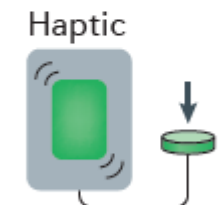
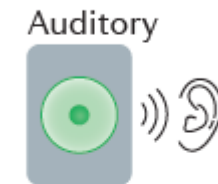
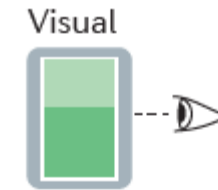
- BMI and its parts
- Learning (retention / transfer)
- Brainwave regulation (SMR)
- Theories behind closed loop brain training
- Feedback, reward and explicit instructions



Closed loop brain training

BMI parts

- Coherence / Connectivity = correlated activity
- Activity / Response = stimuli or task
- Evoked / Induced = phase-lock (average before or after fft)
- Modalities (human senses)



Closed loop brain training

BMI parts...

- Recording method EEG, fMRI, intracortical...
- Signal type VEP, SEP, SSVEP, P300, SMR, rhythms, mu, rhythms...
- Signal processing Filtering, artifact removal, remove noisy trials...
- Feature extraction Coherence, power spectral density (PSD), EEG micro-states, Common Spatial Patterns
- Feedback modality Visual (screen, end-effector), auditory, haptic, electric, tactile, olfactory...

Closed loop brain training

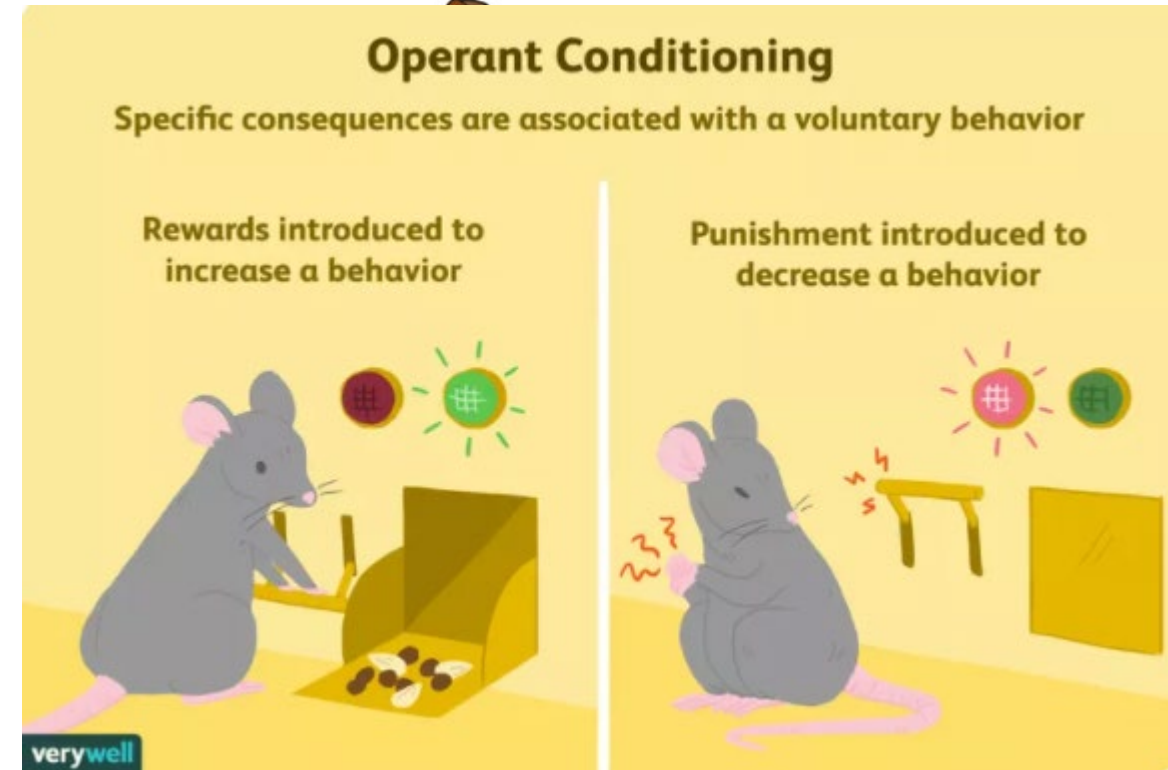
My point...

- There are many methods for each part in a BMI
- You will use
 - EEG
 - SMR-rhythm
 - Filter (frequency)
 - Spectral analysis (or frequency band threshold)
 - Mechanical hand

Closed loop brain training

Learning

- Operant / Instrumental / Reinforcement learning
- Classical conditioning (Pavlovian conditioning)
- Hebbian learning
 - “neurons that fire together, wire together”
 - Potentiation and Depression



www.verywellmind.com/operant-conditioning-a2-2794863



Wikipedia, classical conditioning

Closed loop brain training

Learning

- Delay from stimulus to feedback?
- Retention and Transfer
 - Brain adaptation permanent or transient?
 - Brain adaptation specific or general?

Carnahan, H., Hall, C., & Lee, T. D. (1996). Delayed visual feedback while learning to track a moving target. Research Quarterly for Exercise and Sport, 67(4), 416-423.

Schmidt, R. A. (1991). Frequent augmented feedback can degrade learning: Evidence and interpretations. In Tutorials in motor neuroscience (pp. 59-75). Springer, Dordrecht.

Closed loop brain training

Brainwave regulation

- Humans can modulate their brain activity volitionally
 - Strategy or no strategy
 - (1) no strategy was effective for volitional SMR rhythm modulation
 - (2) Common to use mental strategy (MI) to maximize relevant brain activity
- Assistive VS Rehabilitative BMI
 - Assistive = maximize BMI performance
 - Rehabilitative = Maximize recovery

(1) Kober, S. E., Witte, M., Ninaus, M., Neuper, C., & Wood, G. (2013). Learning to modulate one's own brain activity: the effect of spontaneous mental strategies. Frontiers in human neuroscience, 7, 695.

(2) Ang, K. K., Chua, K. S. G., Phua, K. S., Wang, C., Chin, Z. Y., Kuah, C. W. K., ... & Guan, C. (2015). A randomized controlled trial of EEG-based motor imagery brain-computer interface robotic rehabilitation for stroke. Clinical EEG and neuroscience, 46(4), 310-320.

Closed loop brain training

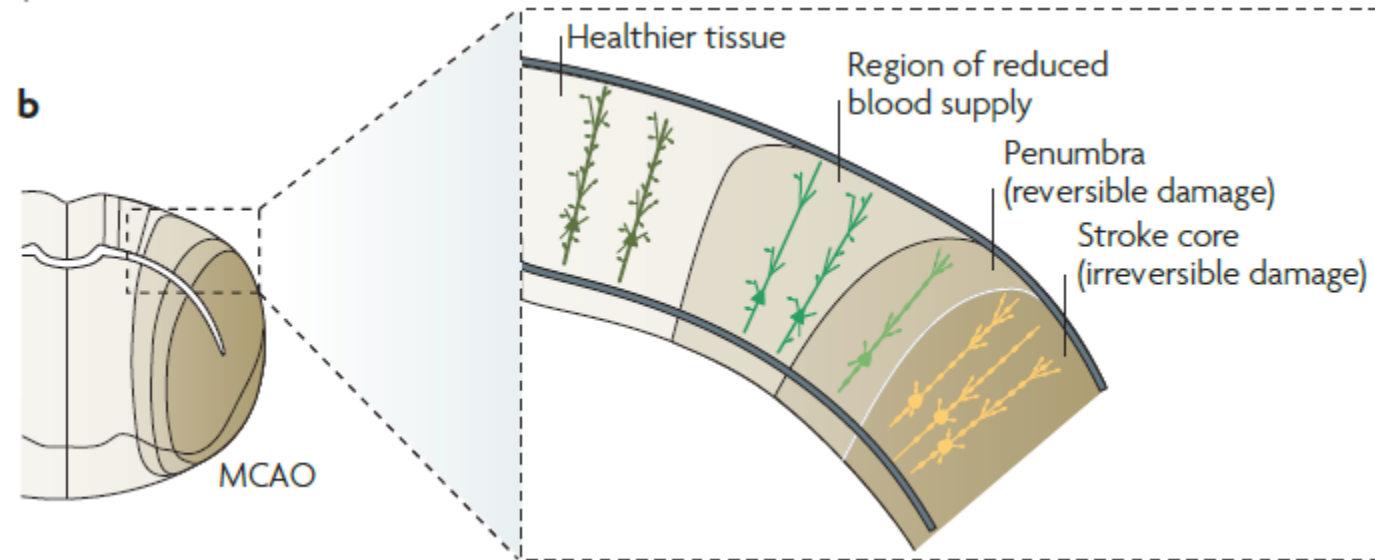
My point...

- There are many ways to generate detectable brain activity
 - Assistive or Rehabilitative
 - Strategy or no strategy
 - Learning or function
- You may do as you wish
 - Motivate choices
 - Remember your limitations (time, hardware, knowledge)

Closed loop brain training

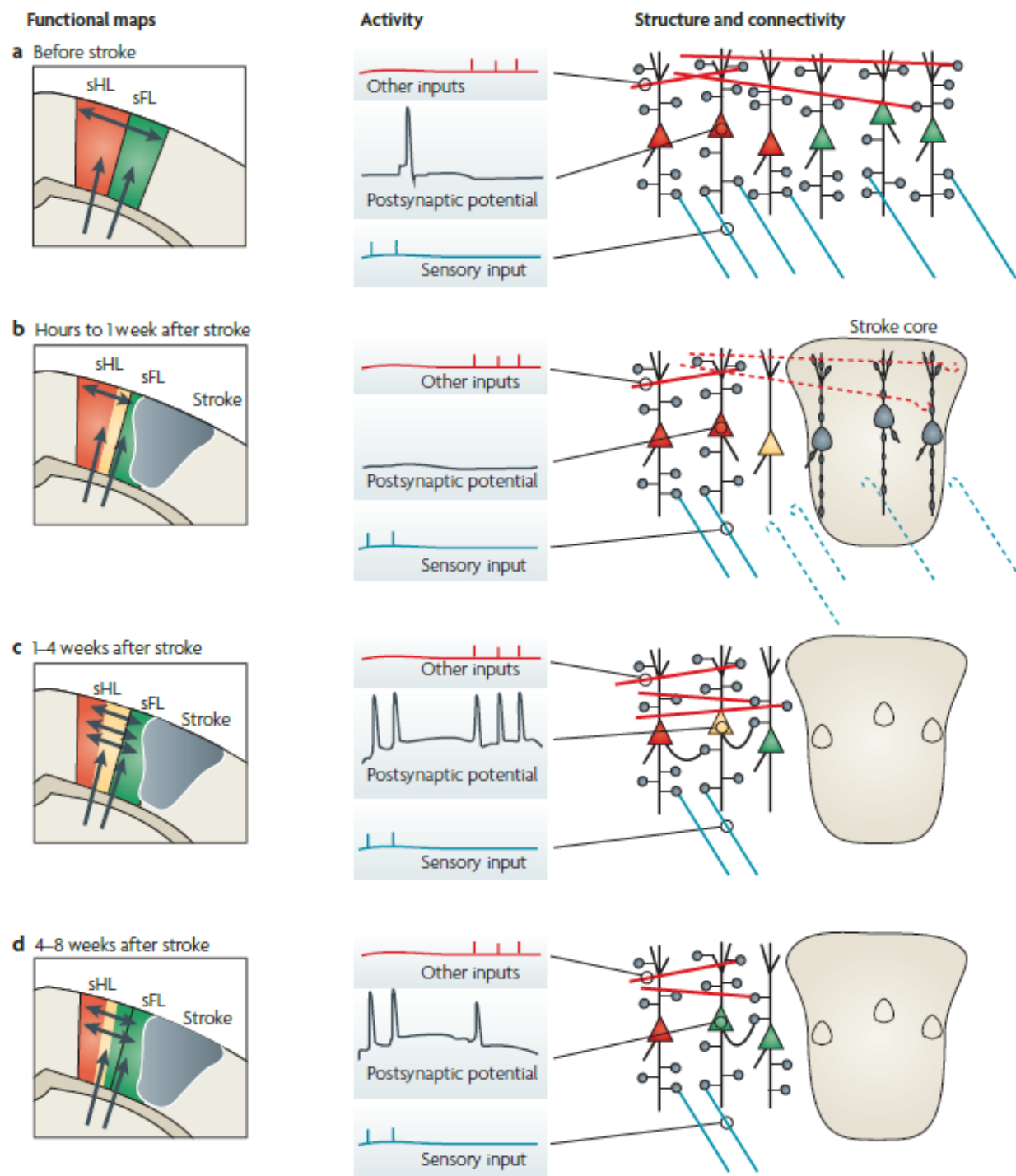
Theories behind closed loop brain training

- Recovery = Learning
 - Neural correlates / mechanisms
 - Functional reorganization
 - Diffuse / redundant connectivity



(1) Murphy, T. H., & Corbett, D. (2009). Plasticity during stroke recovery: from synapse to behaviour. *Nature reviews neuroscience*, 10(12), 861-872.

Example



Closed loop brain training

Theories behind closed loop brain training

- Chronic VS acute
- Window of plasticity
- MI training
- Force the brain to form new synapses
 - CIMT
 - Brush teeth with wrong hand
 - Whipping dough / cream with the wrong hand

Closed loop brain training

My point...

- Common theories behind BCI/BMI rehabilitation
 - Hebbian learning / operant conditioning
 - Open window of neuroplasticity
 - Relevant feedback = relevant functional reorganization

That's all for today

- On Wednesday is the first seminar
- Read Thompson and Glannon (on canvas – Seminars)
 - Upload preparatory task