16.11.23 Donders Session: Biofeedback & Neurofeedback

Clinical applications of fMRI-neurofeedback

David Linden – School for Mental Health and Neuroscience

Maastricht University | Maastricht UMC+

Neurofeedback – a method for self-regulation of the brain

Caria et al., The Neuroscientist, 2011

Design of clinical neurofeedback study

1. What symptom/ syndrome do you want to treat?

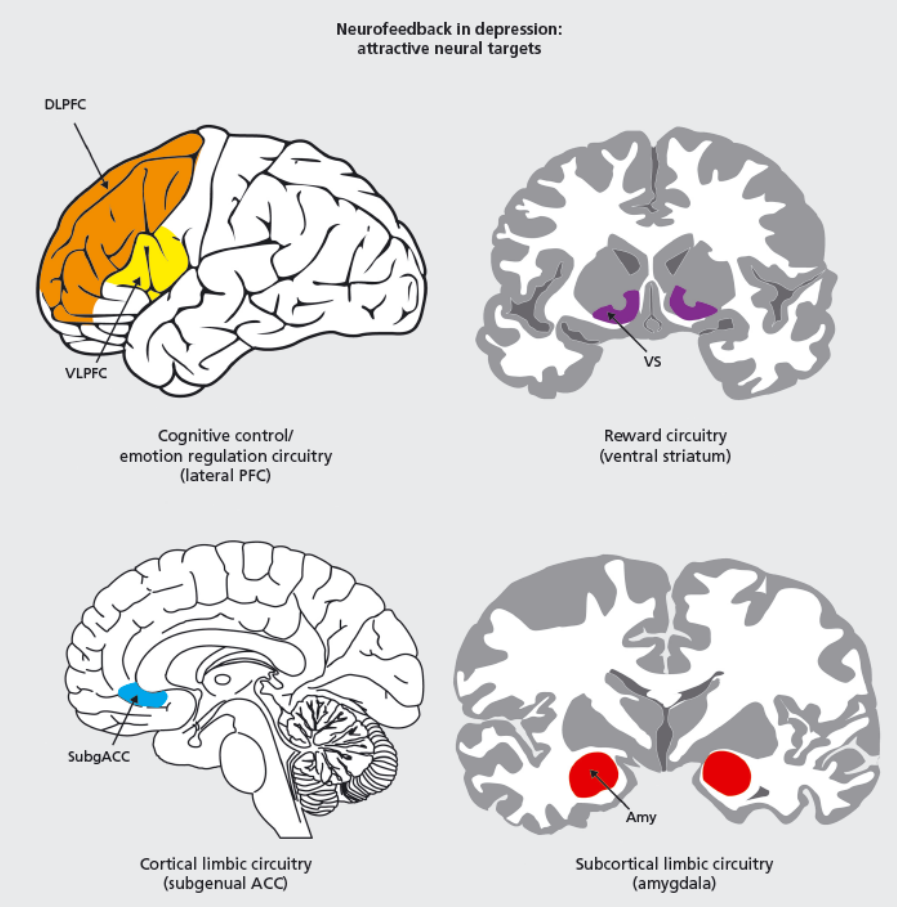
And in which patients?

Psychiatry: Depression

- Improve symptoms of depression (in those who have insufficient response to antidepressants/ psychotherapy) – but what aspect of the clinical syndrome and over what timescale?
- Anhedonia – inability to experience joy, lack of motivation
- Might benefit from both the physiological and psychological mechanisms involved in neurofeedback with focus on experience and regulation of emotions

Mental Imagery training in CBT

Holmes et al., Annu. Rev. Clin. Psychol. , 2016



Linden, Dialogues Clin Neurosci (2014)

Neurology: Parkinson's disease

- Improve hypokinetic symptoms in PD – and possibly reduce dosage of dopaminergic drugs
- Imagery of gait initiation is used in physiotherapy approaches, but effects might be improved by providing feedback about "successful" imagery
- Use neurofeedback of higher motor areas in combination with imagery to improve motor symptoms of PD

Psychiatry: Alcohol dependence

- Help patients maintain abstinence after detoxification – but through what mechanism?
- Craving is a key factor in relapse risk - and is associated with increased responsiveness of motivation circuits to alcohol cues
- Use neurofeedback to teach patients downregulation of this cue reactivity

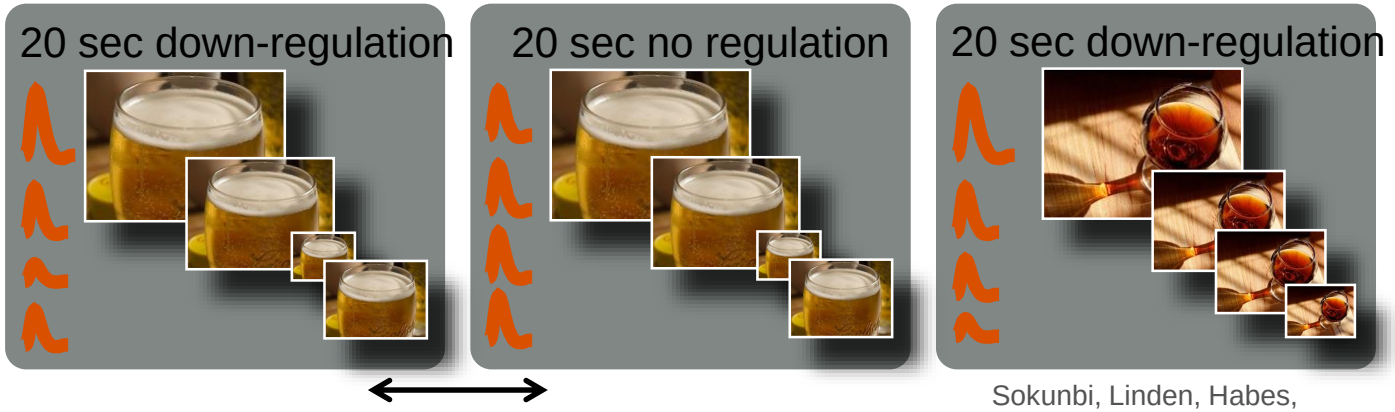
2) What is your mechanistic model for the intervention?

Targeting dysfunctional vs. compensatory activation

- Normalisation of pathological activation
- Recruitment of compensatory circuits
- Re-learning of stimulus-(physiological) response associations

‘Motivational Neurofeedback’

Neurofeedback using picture size variations contingent on target area activation



Sokunbi, Linden, Habes, Johnston, & Ihssen (2014). *Frontiers in BN*.

→ Task provides real motivational consequences (approach and avoidance)

3) What self-regulation protocol to use?

General classification of NF protocols in cognitive/ clinical neuroscience

According to target:

1) Average activation of region-of-interest (or difference between two ROIs)
2) Relationship of activation time course in two or more areas (e.g., partial correlation coefficient, dynamic causal modeling)
3) Multivariate pattern (e.g., MVPA, ICA)

According to feedback signal:

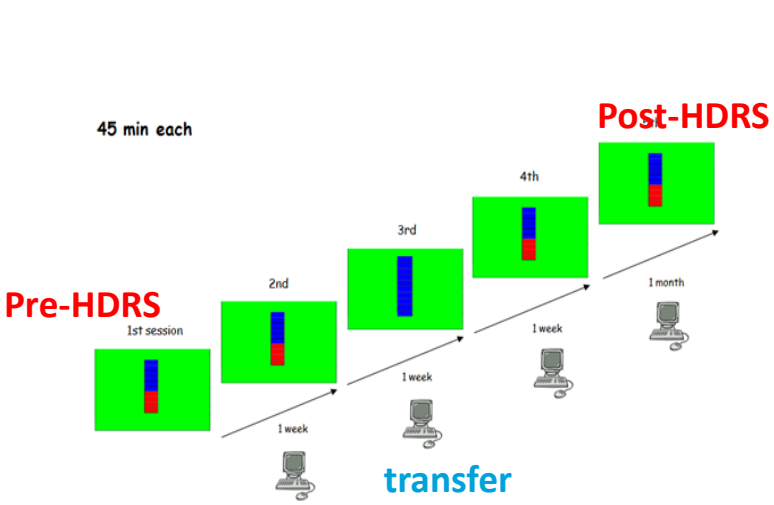
a) Symbolic or analogue feedback (e.g., thermometer)
b) Process-relevant stimulus (e.g., alcohol cue, stressful video scene) – online or delayed

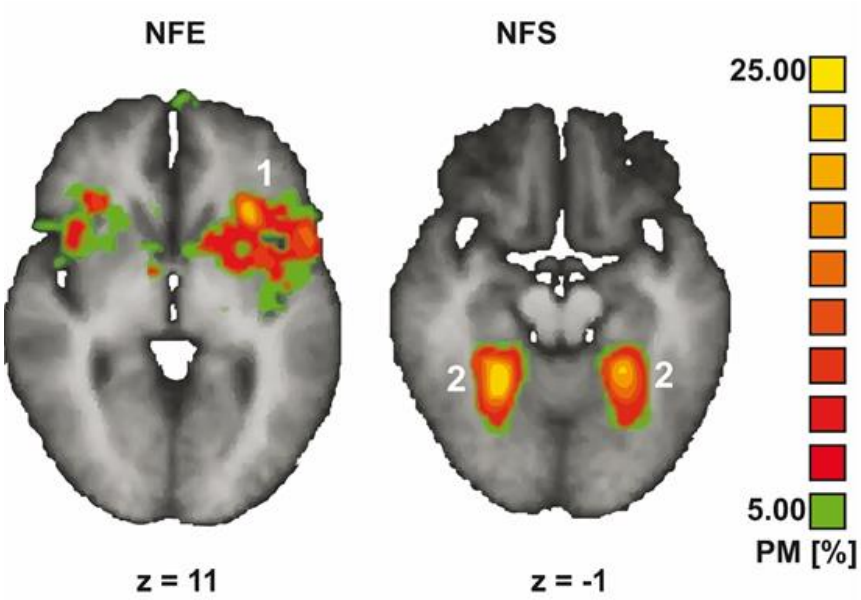
According to strategy/ instructions:

A) Explicit (cognitive)
B) Explicit (operant)
C) Implicit

Clinical example I: Enhancing positive imagery

(classification: 1Aa - average activation, cognitive strategy, simple FB)





Randomised Controlled Trial of fMRI-NF in depression

- Clinical Outcome: Hamilton Depression Rating Scale (**HDRS**)
- Moderate to severe depression despite psychopharmacological treatment (stable dose >3 months);
- Mean time since first episode ~20 years

Neuropsychopharmacology www.nature.com/npp

ARTICLE OPEN

Targeting the affective brain—a randomized controlled trial of real-time fMRI neurofeedback in patients with depression

David M. A. Mehler[1,2], Moses O. Sokunbi[3], Isabelle Habes[2], Kali Barawi[1,2], Leena Subramanian[1,2], Maxence Range[4], John Evans[2], Kerenza Hood[5], Michael Lührs[6,7], Paul Keedwell[1,8], Rainer Goebel[6,7] and David E. J. Linden[1,2,9]

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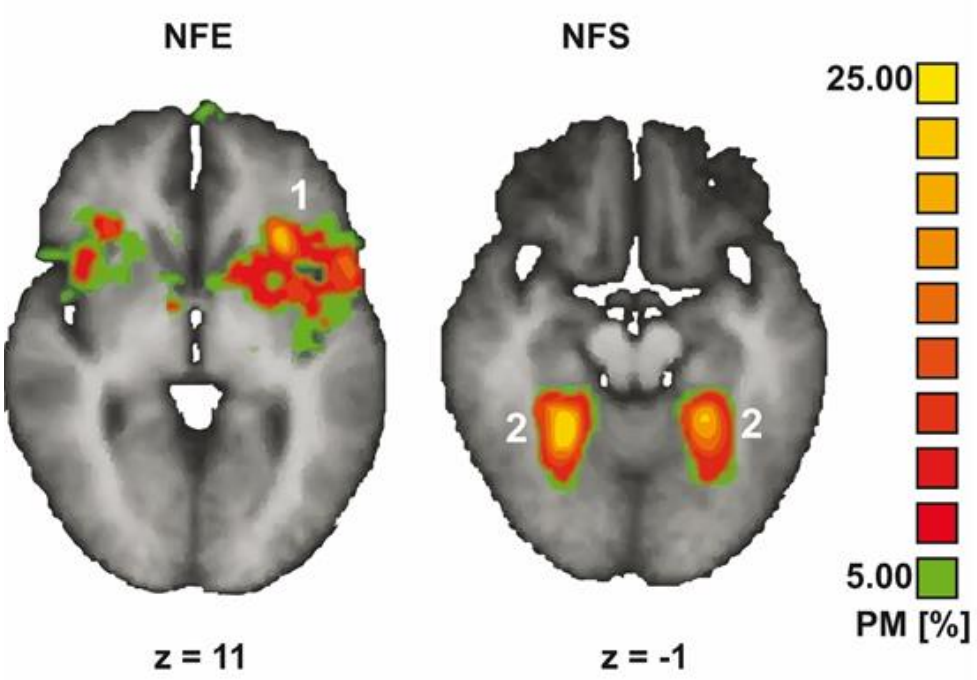
Randomised Controlled Trial

1) NF**E** group (N=16): mental imagery of positive **E**motions
   (e.g. striatal/ paralimbic areas)

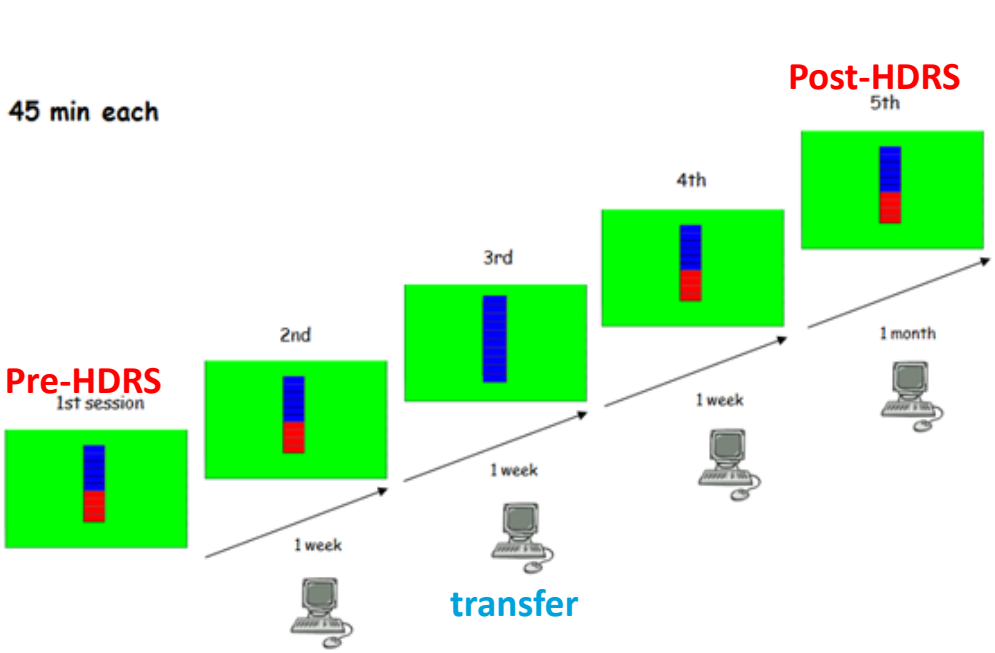
2) NF**S** group (N=16): active control, mental imagery of relaxing **S**cenes (e.g. parahippocampal place area (PPA))

- Passive viewing localiser (NFE: IAPS; NFS: scenes, faces)

Target areas (localiser)

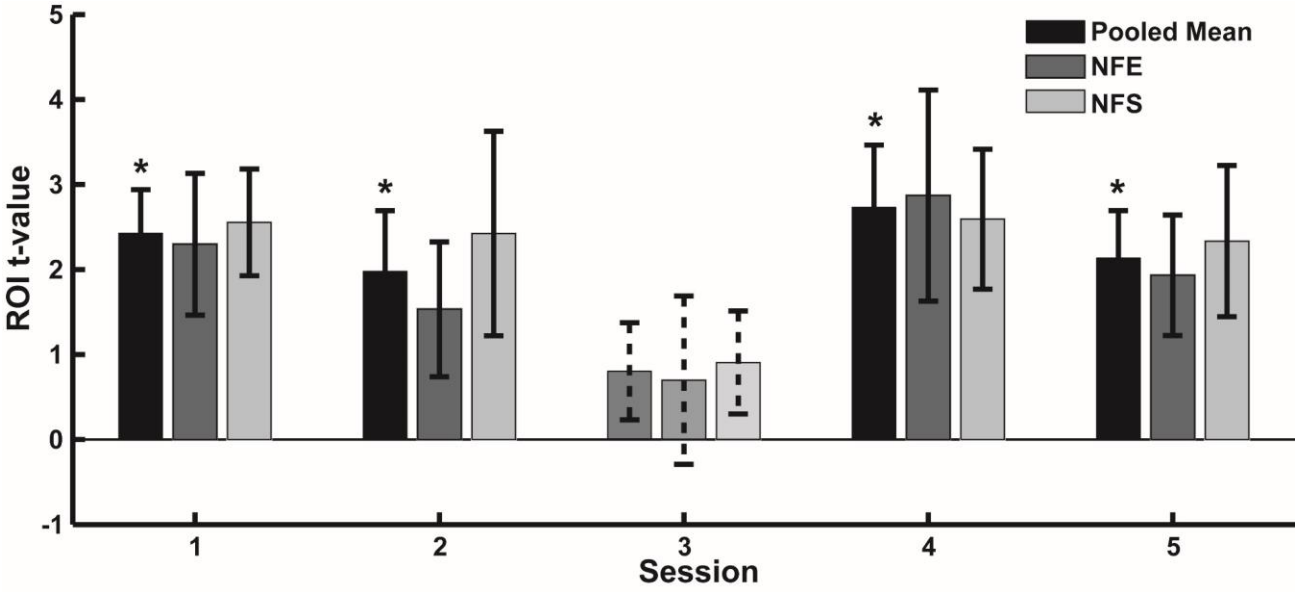


Study Design



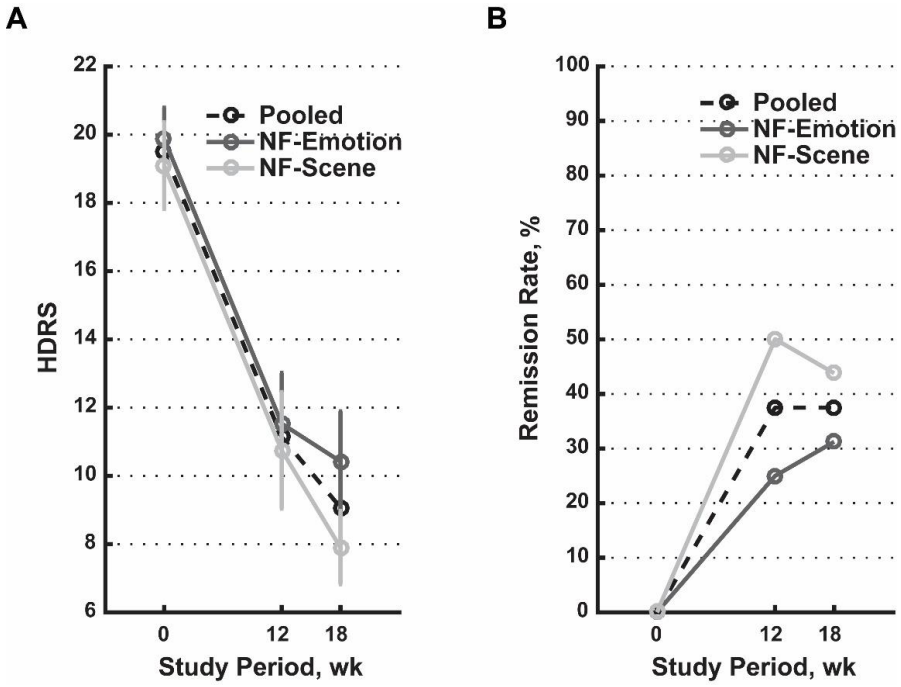
Follow-up
(+6 weeks)

Target region upregulation



Clinical improvement, but no difference between groups

~40% improvement in both groups



Mehler et al., Neuropsychopharmacology (2018)

Comparison with other NF work

Randomized Clinical Trial of Real-Time fMRI Amygdala Neurofeedback for Major Depressive Disorder: Effects on Symptoms and Autobiographical Memory Recall

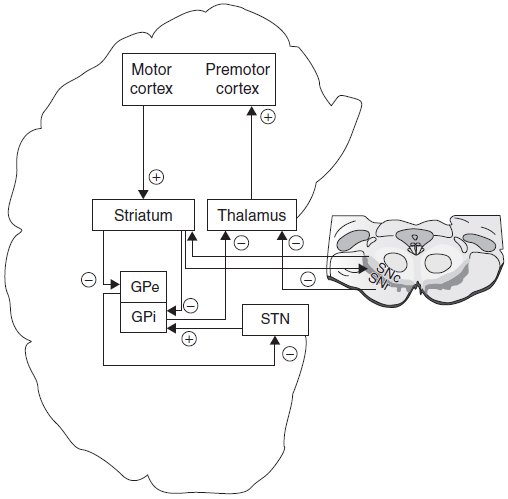
Kymberly D. Young, Ph.D., Greg J. Siegle, Ph.D., Vadim Zotev, Ph.D., Raquel Phillips, B.S., Masaya Misaki, Ph.D., Han Yuan, Ph.D., Wayne C. Drevets, M.D., Jerzy Bodurka, Ph.D.

Young, AJP (2017)

Clinical example II: Activating motor programmes

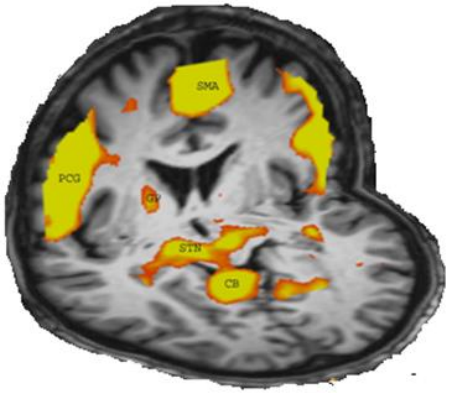
(classification: 1Aa - average activation, cognitive strategy, simple FB)

Motor networks of PD

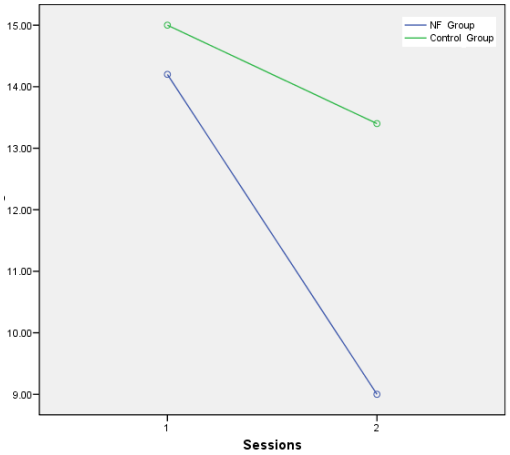


Linden, The Biology of Psychological Disorders, 2019

Activation during NF



Clinical effects: UPDRS scores



The Journal of Neuroscience, November 9, 2011 • 31(45):16309–16317 • 16309

Neurobiology of Disease

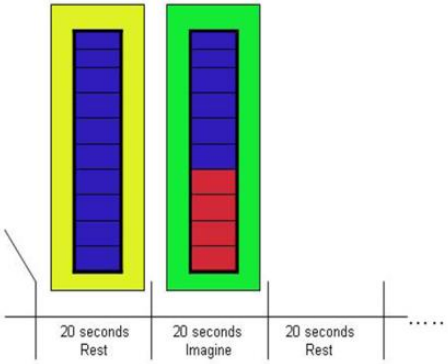
Real-Time Functional Magnetic Resonance Imaging Neurofeedback for Treatment of Parkinson's Disease

Leena Subramanian,[1,2] John V. Hindle,[1] Stephen Johnston,[3] Mark V. Roberts,[1] Masud Husain,[4] Rainer Goebel,[5] and David Linden[1,2,5]

[1]Schools of Psychology and Medical Sciences, Bangor University, Bangor LL57 2AS, United Kingdom, [2]Schools of Medicine and Psychology, Cardiff University, Cardiff CF14 4XN, United Kingdom, [3]School of Social Sciences, Brunel University, Uxbridge UB8 1BY, United Kingdom, [4]Institute of Cognitive Neuroscience, University College London, London WC1N 3AR, United Kingdom, and [5]Department of Cognitive Neuroscience, Maastricht University, 6200 MD Maastricht, The Netherlands

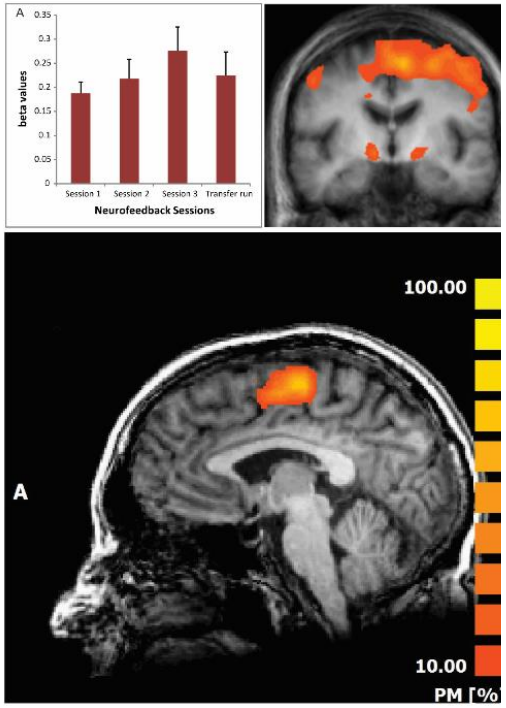
RCT neurofeedback
+ WiiFIt

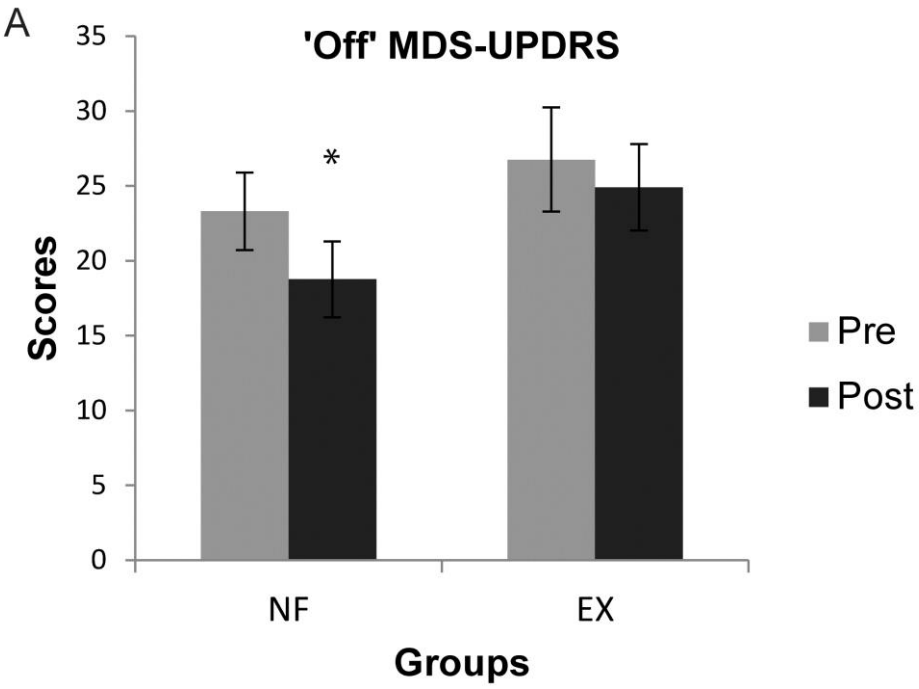
vs. WiiFit only



RCT Neurofeedback for Parkinson‘s Disease

Supplementary Motor Area (SMA)





Subramanian et al, Frontiers Neurosc (2016)

Main Outcomes

- Promising clinical outcome (NF group: improvement of -4.5 points on “off med” MDS-UPDRS motor scale)
- Good feasibility and patient adherence
- Positive feedback from patients
- Power estimate to inform future trials

JPND research
EU Joint Programme – Neurodegenerative Disease Research

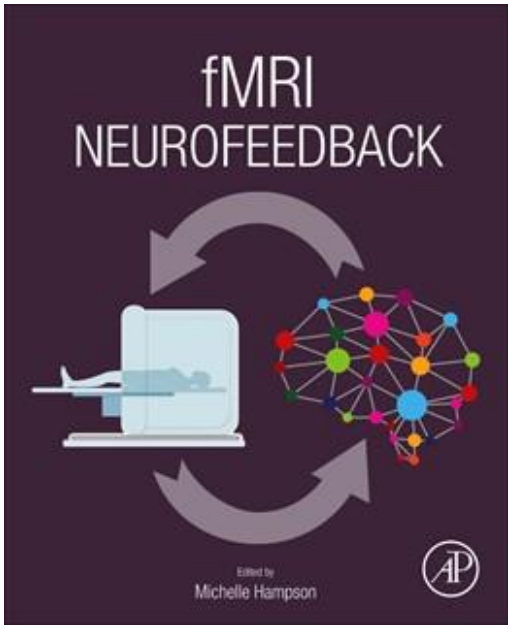
NEURIPIDES
NEURofeedback for self-stImulation of the brain as therapy for ParkInson DisEaSe

https://neuripides.eu/

Next steps

- Depression: demonstrate superiority over TAU and over mental imagery control
- Parkinson: confirm feasibility of basal ganglia neurofeedback
- Better understanding of network effects of DBS
- DBS-inspired protocol in clinical trial

Teaching resources on neurofeedback



Link to keynote lectures real-time fMRI:
https://www.rtfin2019.org/107020/wiki/484037/keynote-speakers

Training workshop rtfin2019:
https://www.rtfin2019.org/107020/wiki/484025/main-speakers

rtFIN 2019
Maastricht – Aachen

real-time functional imaging
and neurofeedback conference

December 7- 11, 2019

SAVE THE DATE: RTFIN 2024

- Functional Imaging and Neurofeedback meeting 2024, 4.-6. November at Heidelberg/Mannheim, Germany

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