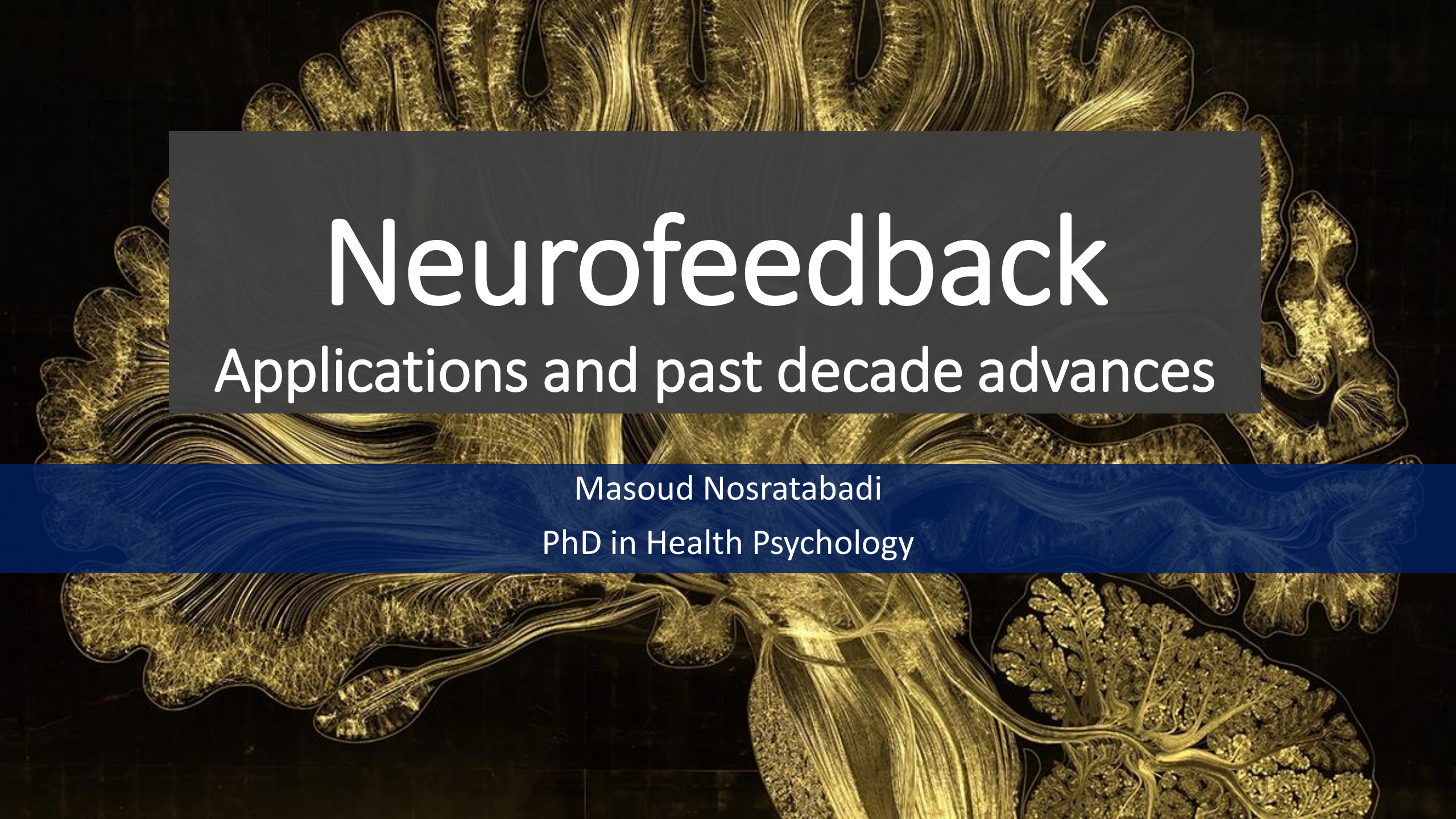


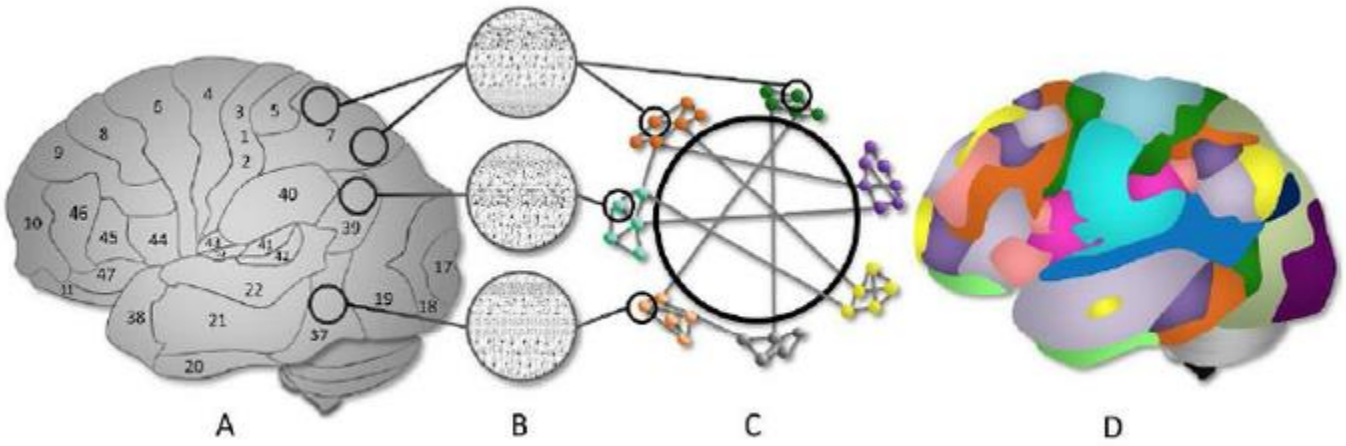
Neurofeedback

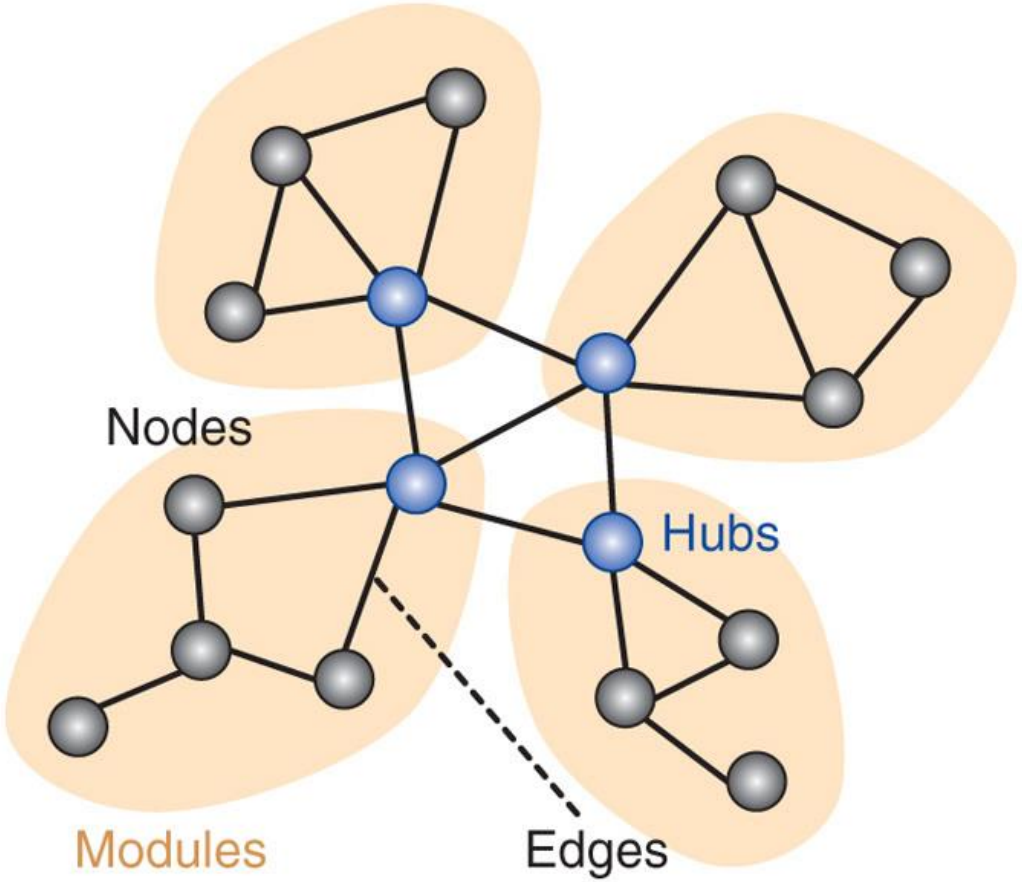
Applications and past decade advances

Masoud Nosratabadi

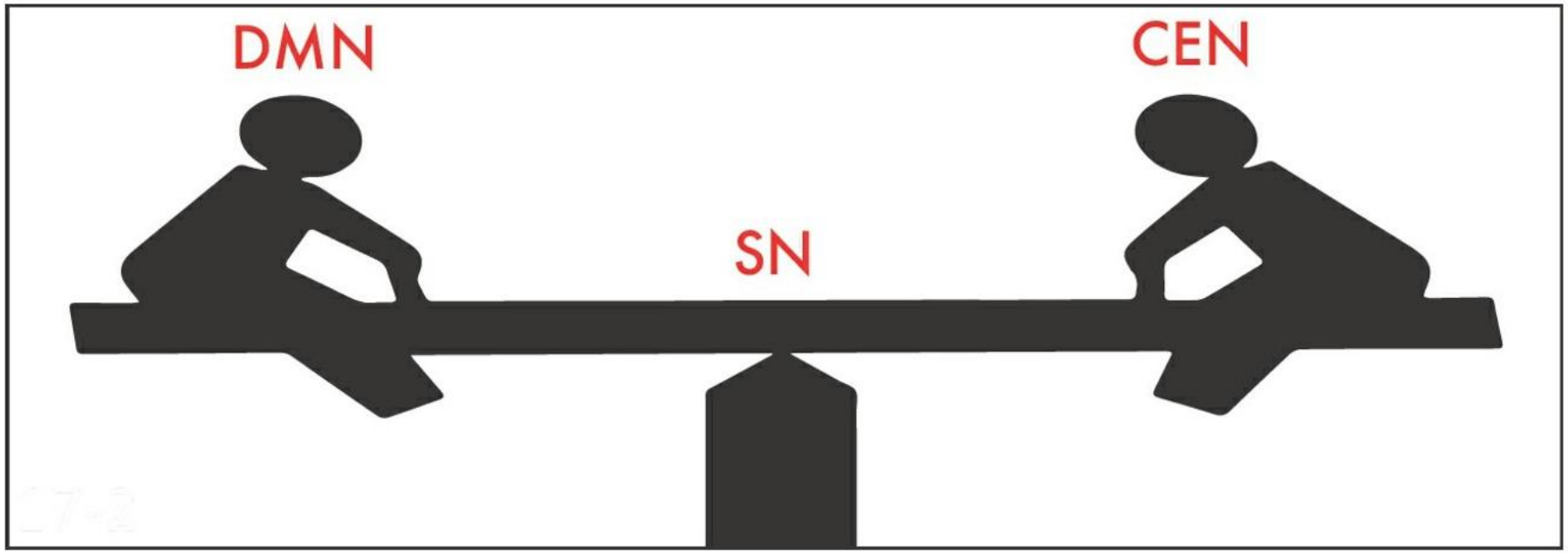
PhD in Health Psychology

Brain Nodes and Networks





Three main Networks
Default Mode Network, Salience Network, Executive Network



	ROI'S	FUNCTION	DISORDERS/ process
DEFAULT (DMN)	AG, ACC, IPL, MFG, MTG, PH, PCC, RG, PRECUN, SbG (25), SFG, STG, TTG	SENSE OF SELF, Reflections, dreams, goals, "internal" communication	Borderline PD, all PD's, Bipolar, ASD, schizophrenia, Codependency, Type A Personality, Alzheimer's, Etc.
SALIENCE (SN)	ACC, INS Brodmann: 6, 13, 24, 32, 33, 44, 45, 47	"External" communication, social behavior, and self-awareness Integration of sensory, emotional, & cognitive info	ADHD, "attention"
CENTRAL EXE (CEN)	IPL, SPL, SM, MFG Brodmann: 7, 8, 9, 46	High level cognitive functions such as planning, decision making, and the control of attention and working mem	Associated with Hi-IQ in adolescents. Help to suppress the DMN and allow for better exec-functions. Hence "control"

Three main aims of any Neurofeedback modalities

1- modifying arousal features of brain (Nodes)

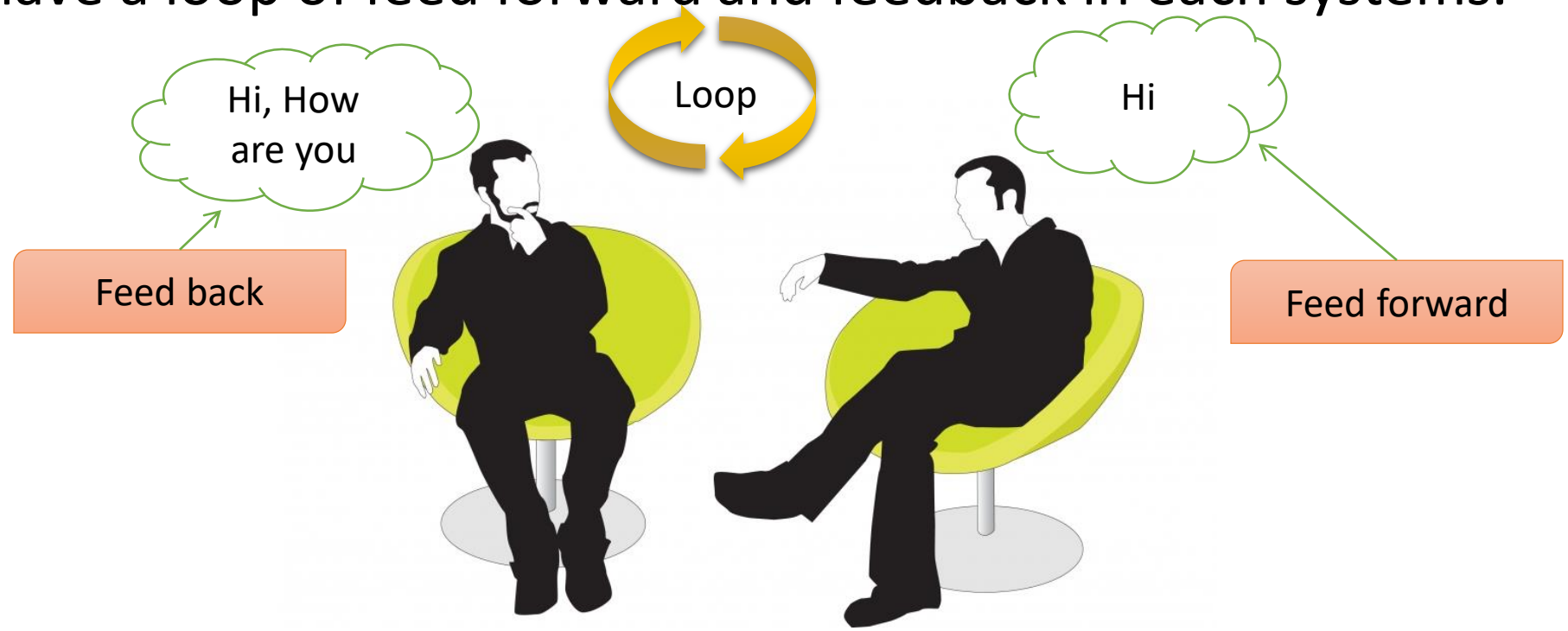
2- Modifying connectivity features (Networks)

3- Deep state training (Alpha-Theta)

What is Neurofeedback

- We have a puzzle for understanding neurofeedback mechanism
  - A) Feedback
  - B) Learning psychology

- In general theory of systems, each system has at least tow parts which communicate with each other
- We have a loop of feed forward and feedback in each systems.



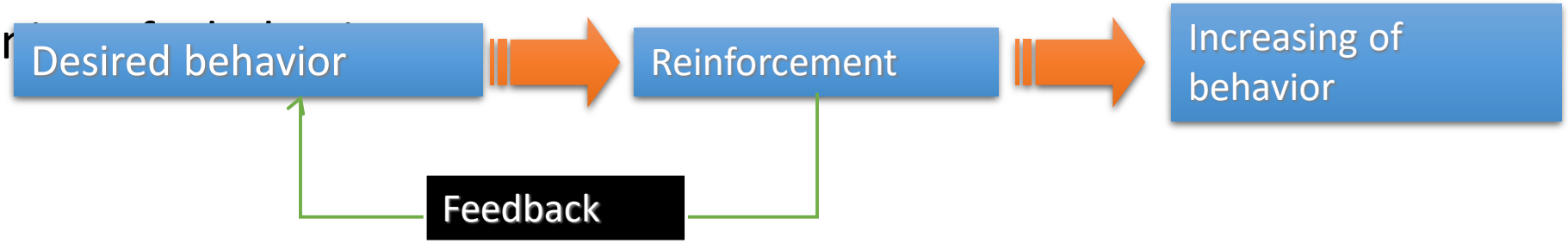
- Our brain works based on feed forward and feedback loops too.
- The result of this loop is **Self Regulation**.

Learning Psychology

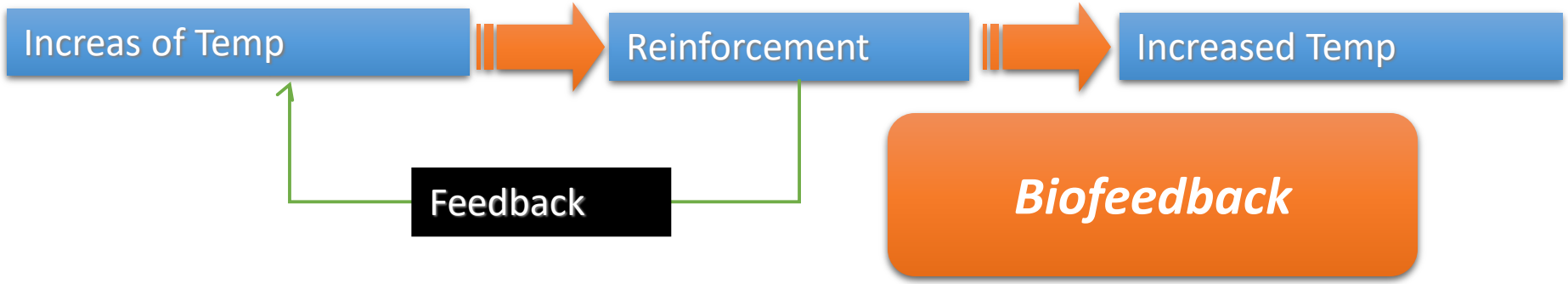
- One of main subjects in learning psychology is conditioning.
- We have two type of conditioning: Classic conditioning & Operant Conditioning.
- Neurofeedback generally works based on Operant conditioning.

Learning Psychology

- Learr

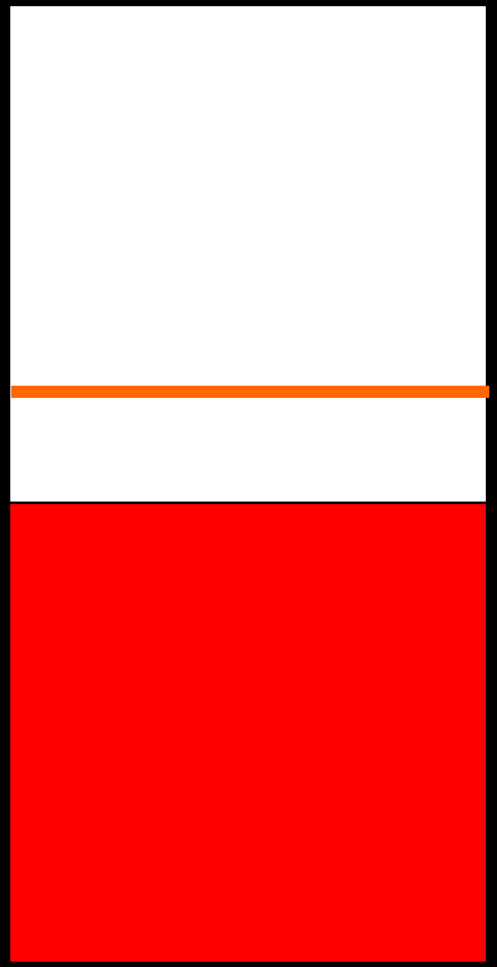


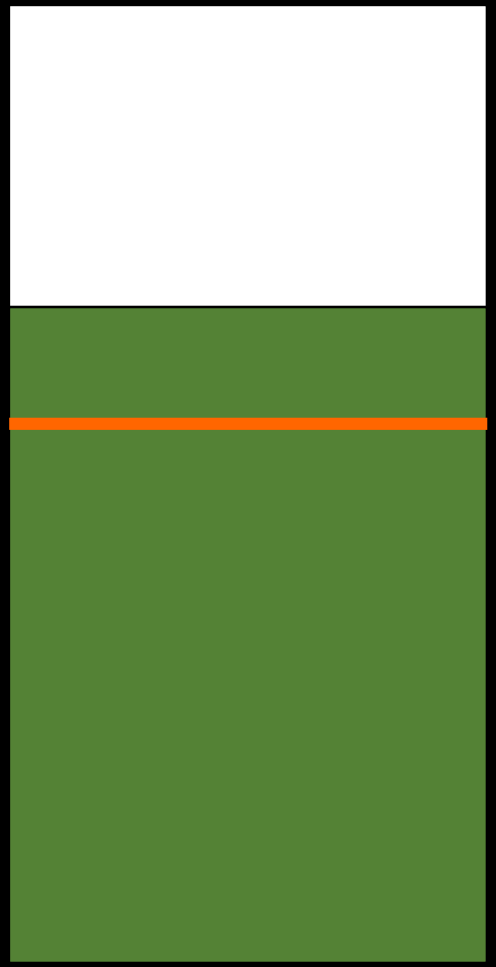
- Learning of a change in biological responses

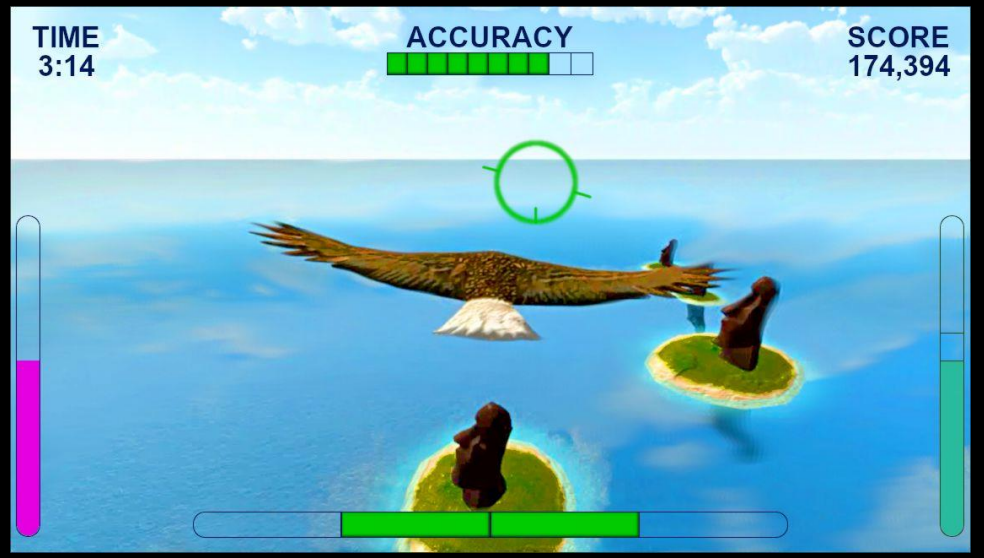


Other main principle of learning

- Shaping
  - A process of behavior modification in which the likelihood of a specific behavior is increased or decreased through positive or negative reinforcement each time the behavior is exhibited, so that the subject comes to associate the pleasure or displeasure of the reinforcement with the behavior.





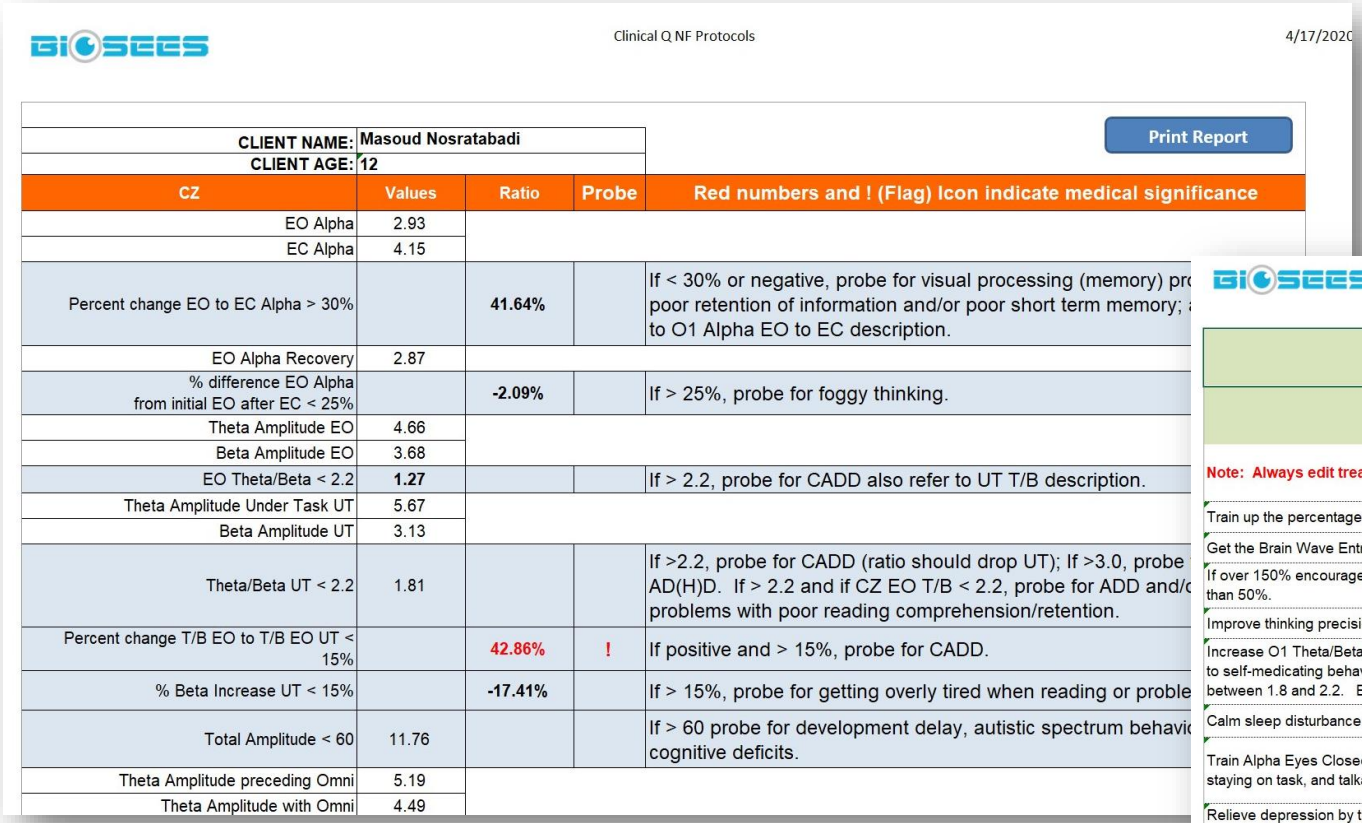

TIME
3:14
ACCURACY
SCORE
174,394

EEG based Neurofeedback techniques

Training protocol	Target neural signature	Common applications	Principal evidence (observable changes)
Theta/beta	↑ subset of 12–21 Hz (12–15 Hz is SMR training) ↓ 4–8 Hz	ADHD, epilepsy	ADHD rating scales, seizure frequency, resting-state EEG, resting-state fMRI
SCP	↑ and ↓ resting-state electronegativity	ADHD, epilepsy	subjective measures, resting-state EEG, resting-state fMRI, seizure frequency
Upper/peak alpha	↑ alpha frequency that is already largest in amplitude (often 9–11 Hz)	athletic and cognitive performance	cognitive tasks
Low resolution electromagnetic tomography	↑ or ↓ activity of select brain regions (often the anterior cingulate)	cognitive enhancement	intelligence tests
Theta+alpha	↑ 4–13 Hz	alcoholism	prevention of relapse
Theta/alpha	↑ 4–8 Hz ↓ 8–13 Hz	creativity	artistic performance
Live z score[a]	normalize the amplitude and coherence of all waveforms (visual and auditory feedback)	any disorder	subjective measures
Low energy neurofeedback system[a]	normalize the amplitude and coherence of all waveforms (electrical pulse feedback)	any disorder	subjective measures

[a] The last two trainings are commercial techniques.

Symptom based NF

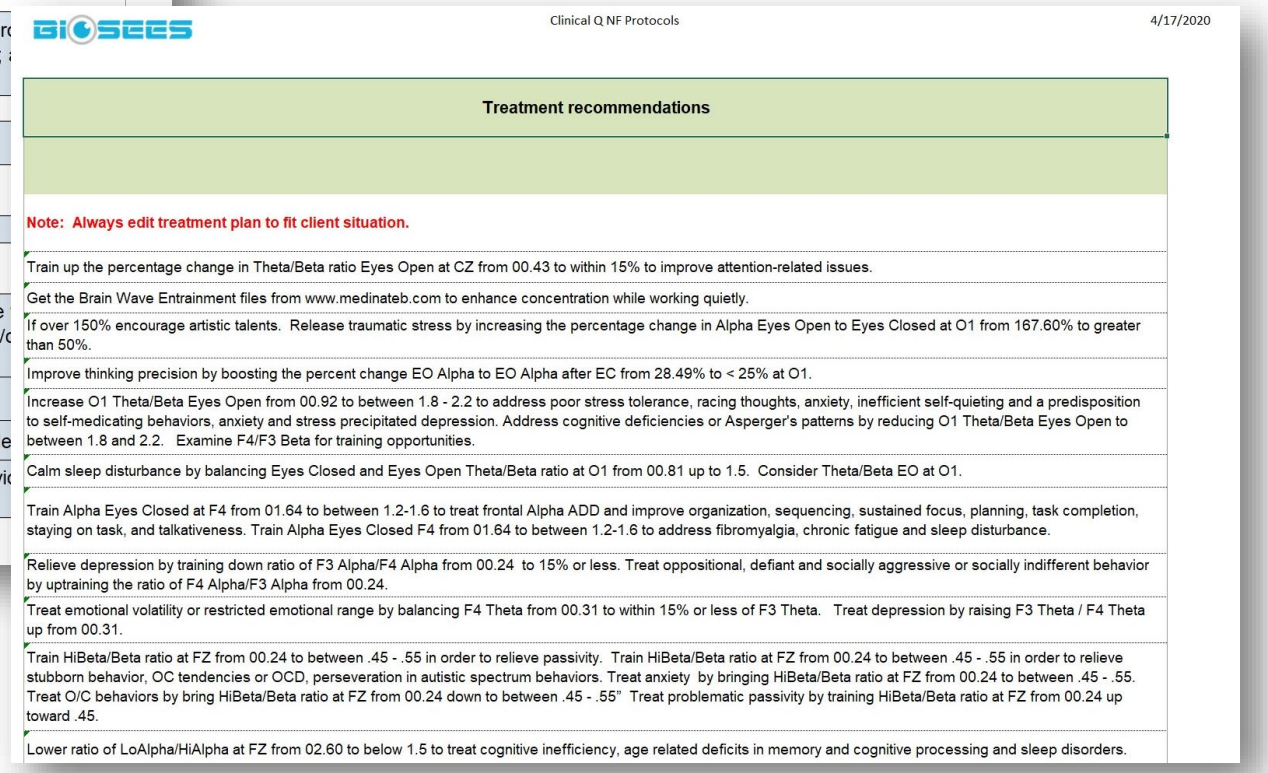


BIOSEES Clinical Q NF Protocols 4/17/2020

CLIENT NAME: Masoud Nosratabadi
CLIENT AGE: 12

Print Report

CZ	Values	Ratio	Probe	Red numbers and ! (Flag) Icon indicate medical significance
EO Alpha	2.93			
EC Alpha	4.15			
Percent change EO to EC Alpha > 30%		41.64%		If < 30% or negative, probe for visual processing (memory) pr poor retention of information and/or poor short term memory; to O1 Alpha EO to EC description.
EO Alpha Recovery	2.87			
% difference EO Alpha from initial EO after EC < 25%		-2.09%		If > 25%, probe for foggy thinking.
Theta Amplitude EO	4.66			
Beta Amplitude EO	3.68			
EO Theta/Beta < 2.2	1.27			If > 2.2, probe for CADD also refer to UT T/B description.
Theta Amplitude Under Task UT	5.67			
Beta Amplitude UT	3.13			
Theta/Beta UT < 2.2	1.81			If >2.2, probe for CADD (ratio should drop UT); If >3.0, probe AD(H)D. If > 2.2 and if CZ EO T/B < 2.2, probe for ADD and/ problems with poor reading comprehension/retention.
Percent change T/B EO to T/B EO UT < 15%		42.86%	!	If positive and > 15%, probe for CADD.
% Beta Increase UT < 15%		-17.41%		If > 15%, probe for getting overly tired when reading or proble
Total Amplitude < 60	11.76			If > 60 probe for development delay, autistic spectrum behavi cognitive deficits.
Theta Amplitude preceding Omni	5.19			
Theta Amplitude with Omni	4.49			



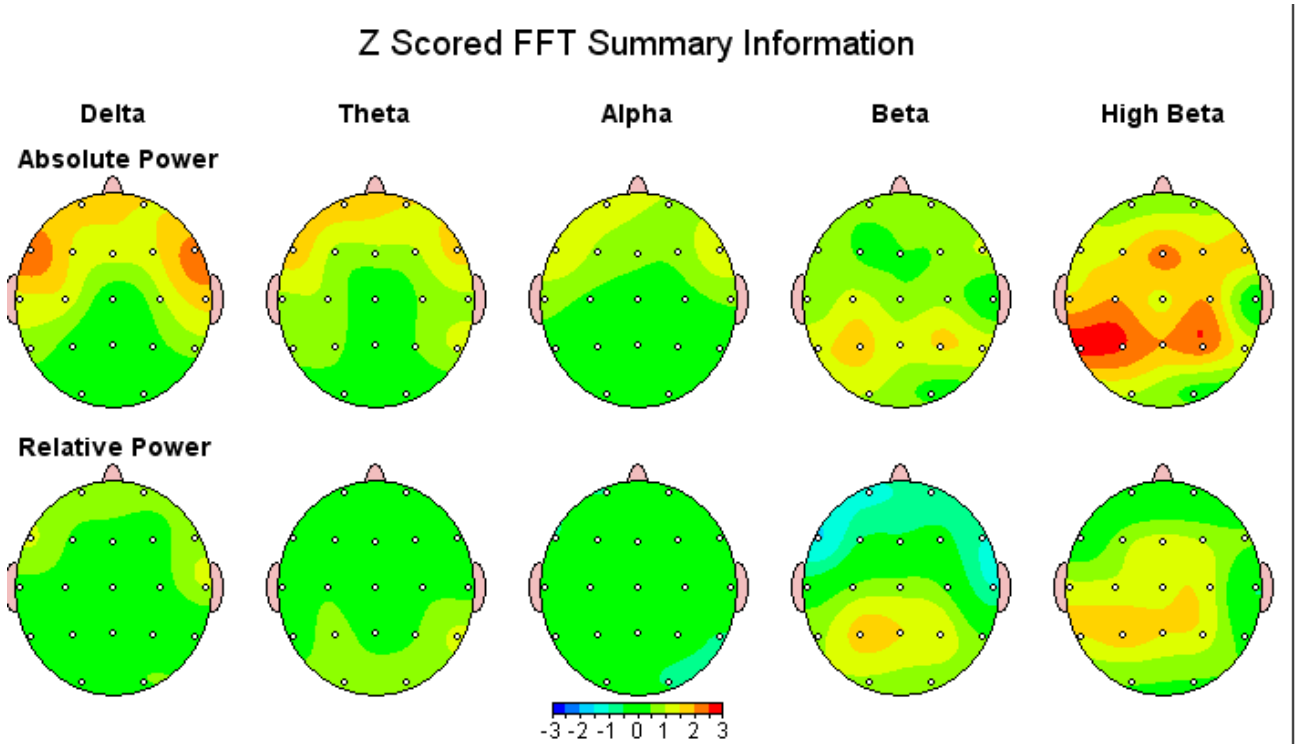
BIOSEES Clinical Q NF Protocols 4/17/2020

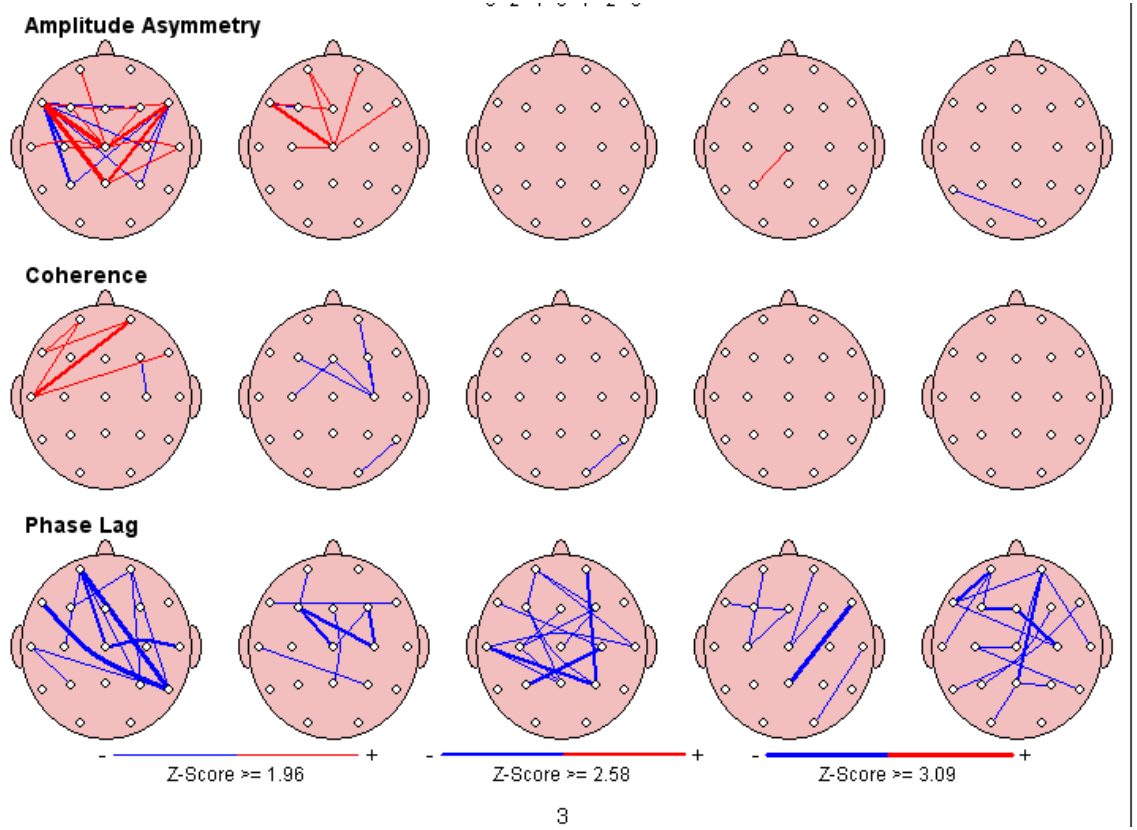
Treatment recommendations

Note: Always edit treatment plan to fit client situation.

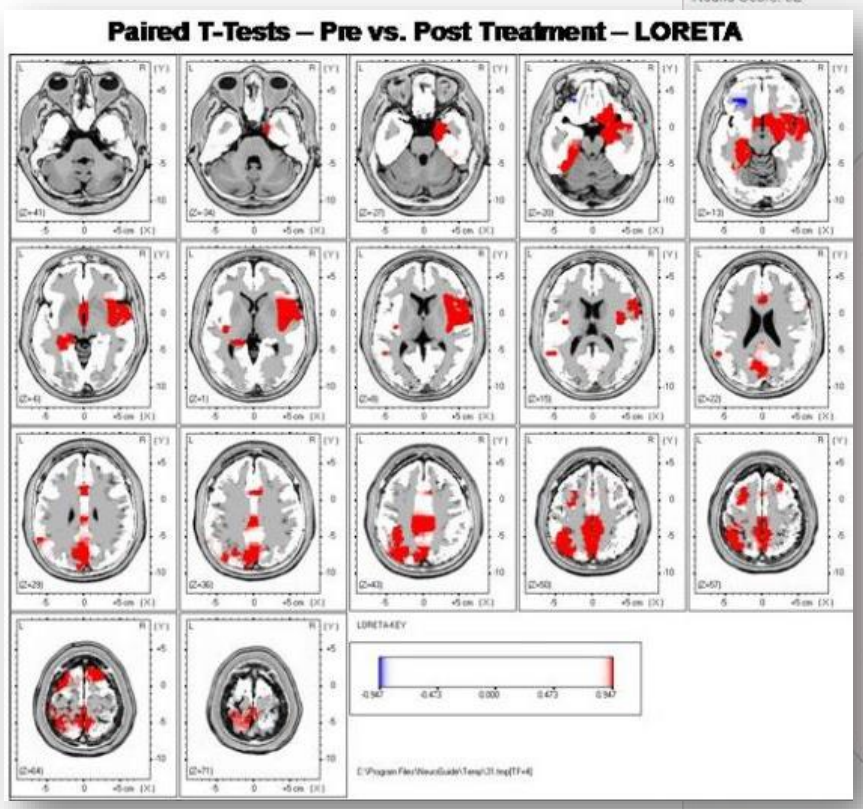
- Train up the percentage change in Theta/Beta ratio Eyes Open at CZ from 00.43 to within 15% to improve attention-related issues.
- Get the Brain Wave Entrainment files from www.medinateb.com to enhance concentration while working quietly.
- If over 150% encourage artistic talents. Release traumatic stress by increasing the percentage change in Alpha Eyes Open to Eyes Closed at O1 from 167.60% to greater than 50%.
- Improve thinking precision by boosting the percent change EO Alpha to EO Alpha after EC from 28.49% to < 25% at O1.
- Increase O1 Theta/Beta Eyes Open from 00.92 to between 1.8 - 2.2 to address poor stress tolerance, racing thoughts, anxiety, inefficient self-quieting and a predisposition to self-medicating behaviors, anxiety and stress precipitated depression. Address cognitive deficiencies or Asperger's patterns by reducing O1 Theta/Beta Eyes Open to between 1.8 and 2.2. Examine F4/F3 Beta for training opportunities.
- Calm sleep disturbance by balancing Eyes Closed and Eyes Open Theta/Beta ratio at O1 from 00.81 up to 1.5. Consider Theta/Beta EO at O1.
- Train Alpha Eyes Closed at F4 from 01.64 to between 1.2-1.6 to treat frontal Alpha ADD and improve organization, sequencing, sustained focus, planning, task completion, staying on task, and talkativeness. Train Alpha Eyes Closed F4 from 01.64 to between 1.2-1.6 to address fibromyalgia, chronic fatigue and sleep disturbance.
- Relieve depression by training down ratio of F3 Alpha/F4 Alpha from 00.24 to 15% or less. Treat oppositional, defiant and socially aggressive or socially indifferent behavior by uptraining the ratio of F4 Alpha/F3 Alpha from 00.24.
- Treat emotional volatility or restricted emotional range by balancing F4 Theta from 00.31 to within 15% or less of F3 Theta. Treat depression by raising F3 Theta / F4 Theta up from 00.31.
- Train HiBeta/Beta ratio at FZ from 00.24 to between .45 - .55 in order to relieve passivity. Train HiBeta/Beta ratio at FZ from 00.24 to between .45 - .55 in order to relieve stubborn behavior, OC tendencies or OCD, perseveration in autistic spectrum behaviors. Treat anxiety by bringing HiBeta/Beta ratio at FZ from 00.24 to between .45 - .55. Treat O/C behaviors by bring HiBeta/Beta ratio at FZ from 00.24 down to between .45 - .55" Treat problematic passivity by training HiBeta/Beta ratio at FZ from 00.24 up toward .45.
- Lower ratio of LoAlpha/HiAlpha at FZ from 02.60 to below 1.5 to treat cognitive inefficiency, age related deficits in memory and cognitive processing and sleep disorders.

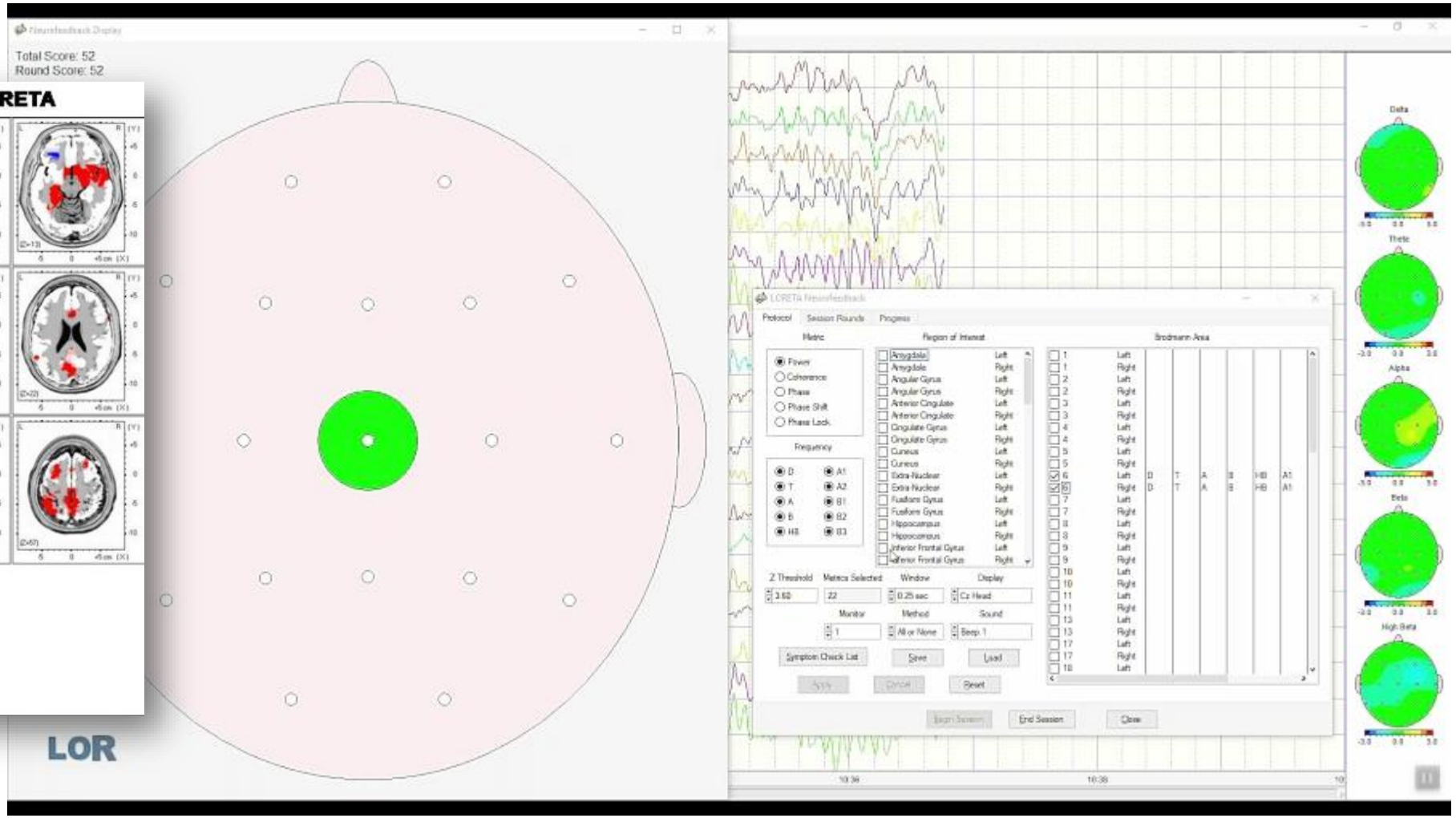
QEEG Guided NF

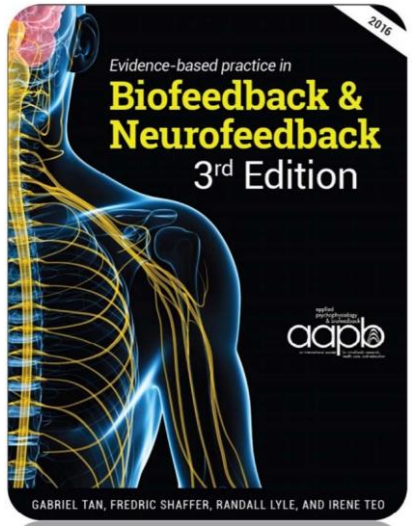




LORETA NF

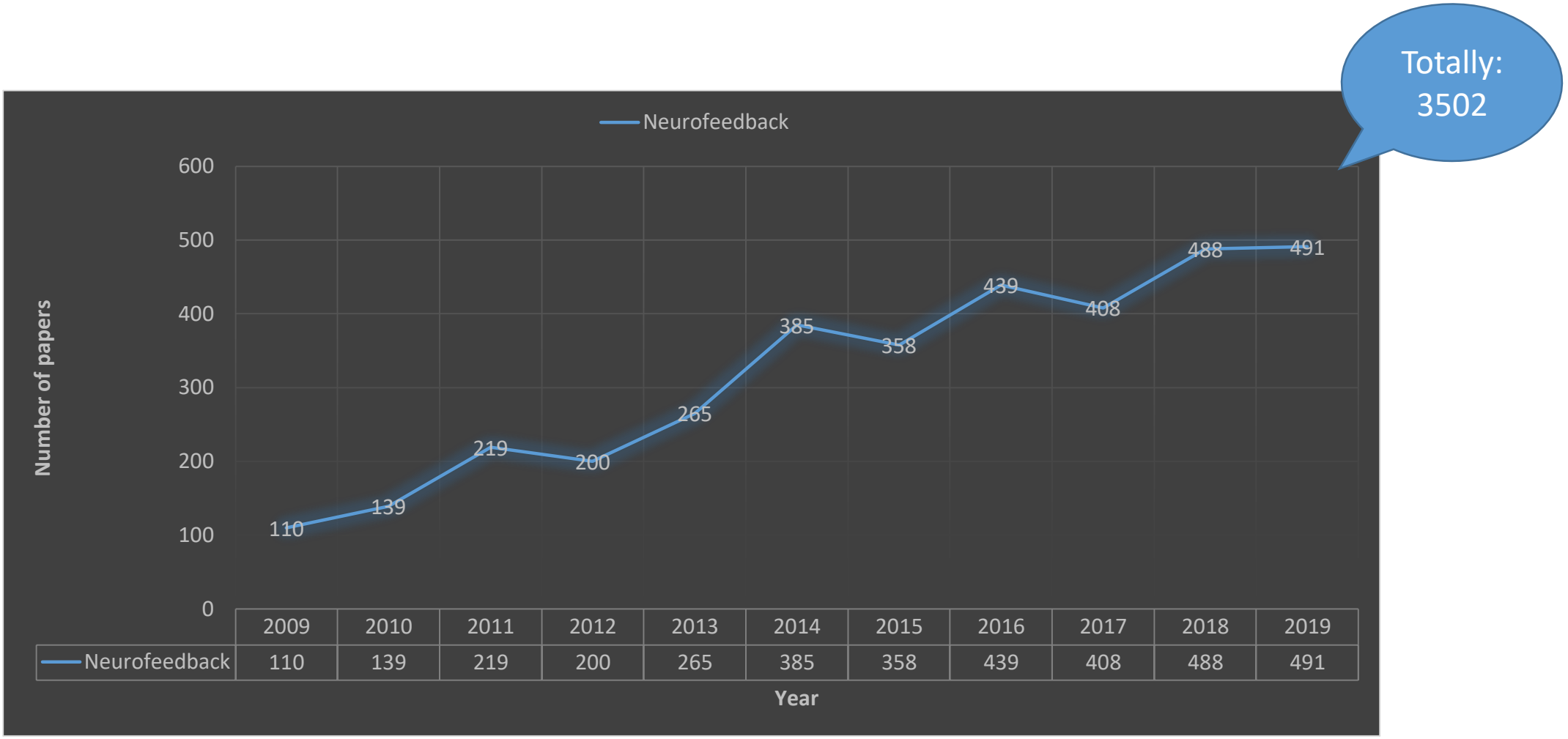

Paired T-Tests – Pre vs. Post Treatment – LORETA
LORETA-KEY


Total Score: 52
Round Score: 52
LOR
Delta
Theta
Alpha
Beta
High Beta

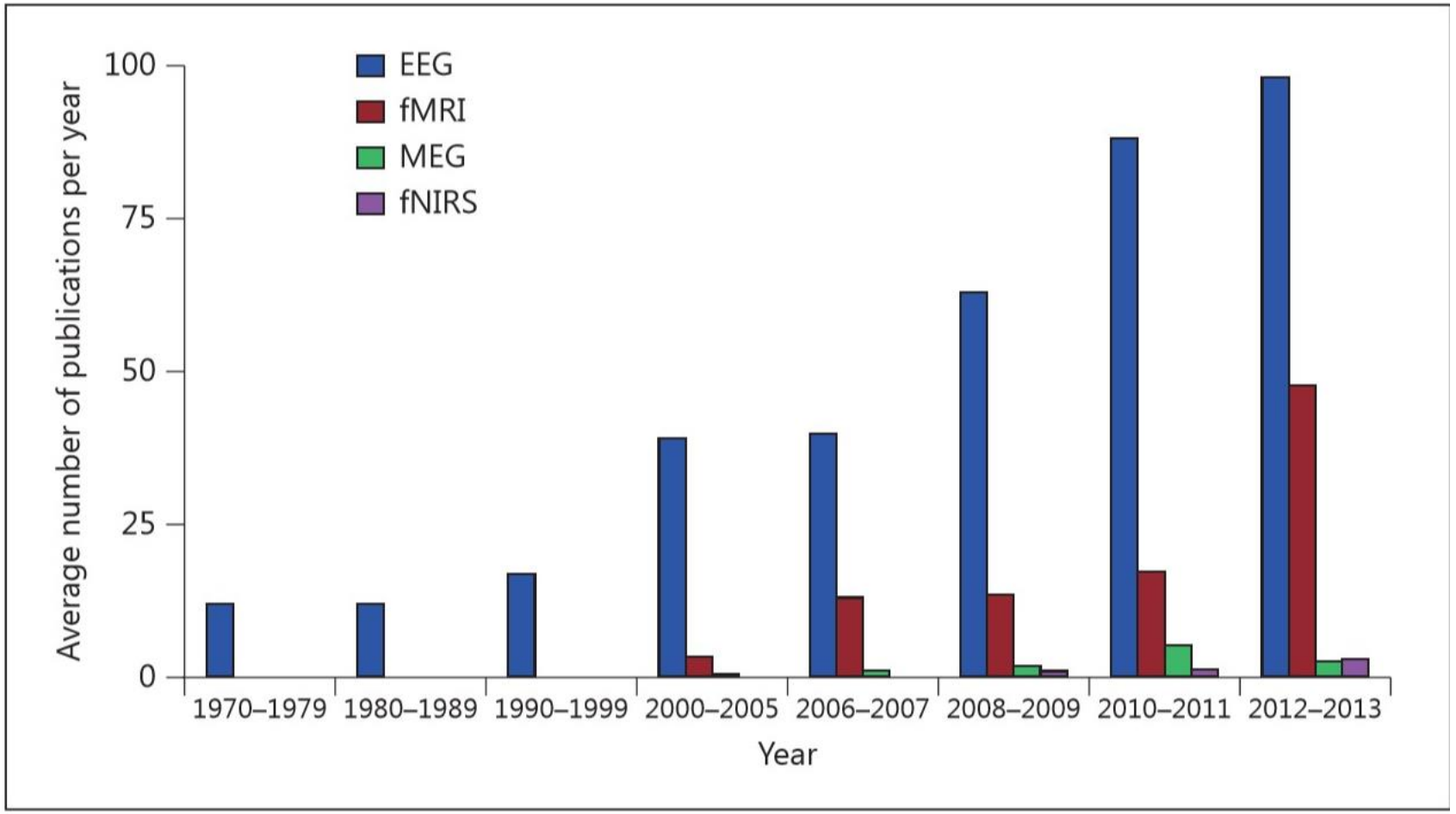


اختلال/مشکل	سطح اثربخشی	ماژول مورد استفاده
سوء مصرف مواد/الکل	سطح ۳	نوروفیدبک
اضطراب	سطح ۴	نوروفیدبک/HRV/EMG
بیش‌فعالی/نقص توجه	سطح ۵	نوروفیدبک
اتیسم	سطح۳	نوروفیدبک
افسردگی (غیر از MD)	سطح ۴	نوروفیدبک/HRV
صرع	سطح ۴	نوروفیدبک
فیبرومایالژیا	سطح ۳	نوروفیدبک/EMG
اختلال خواب (Insomnia)	سطح ۳	نوروفیدبک
بیماری مزمن انسداد ریوی (COPD)	سطح ۲	HRV
تینیتوس	سطح ۳	EMG/SC
	سطح ۲	نوروفیدبک
آسیب‌های مغزی (TBI)	سطح ۳	نوروفیدبک
بهبود کارکردهای شناختی	سطح ۳	نوروفیدبک/ سایر ماژولهای بیوفیدبک
ناتوانی یادگیری	سطح ۳	نوروفیدبک
سردرد (تنشی/میگرن)	سطح ۴	نوروفیدبک/Temp/EMG
آرتروز	سطح ۳	EMG
آسم	سطح ۳	HRV/Resp
فلج مغزی (بهبود مولفه های حرکتی)	سطح ۲	EMG
یبوست	سطح ۴	EMG/Pelvic Floor
بیماری عروق کرونر	سطح ۲	HRV
اختلال استرس پس از سانحه (PTSD)	سطح ۳	نوروفیدبک/HRV
فشار خون	سطح ۴	EMG/HRV
فشار خون حاملگی	سطح ۴	SC/HRV

Research Papers (PubMed + Science Direct)



Neurofeedback Modalities



Neurofeedback Modalities

Table 1. Popularity, cost, and availability of neurofeedback modalities

	EEG	fMRI	MEG	fNIRS
First application to neurofeedback	1958	2003	2005	2007
Practitioners worldwide, n	>1,000	none	none	none
Research laboratories, n[a]	>50	~10	3	~5
Cost of initial set-up, USD	500–5,000 (personal use) 5,000–50,000 (research use)	500,000–2,000,000	2,000,000	50,000–300,000
Running costs, USD[b]	no extra fees	~500/h	~500/h	no extra fees
Cost for patient, USD[c]	130–225/session 4,000–10,000/ complete regimen	not available to patients	not available to patients	not available to patients
Marketed equipment	many companies sell products for clinical, research, and personal uses	one software package for research use only	none (all laboratories run in-house software)	none (all laboratories run in-house software)

Currently, practitioners leverage only EEG-nf in the clinic. Alternatively, fMRI-, MEG-, and fNIRS-nf are costly and lack evidence for clinical application.

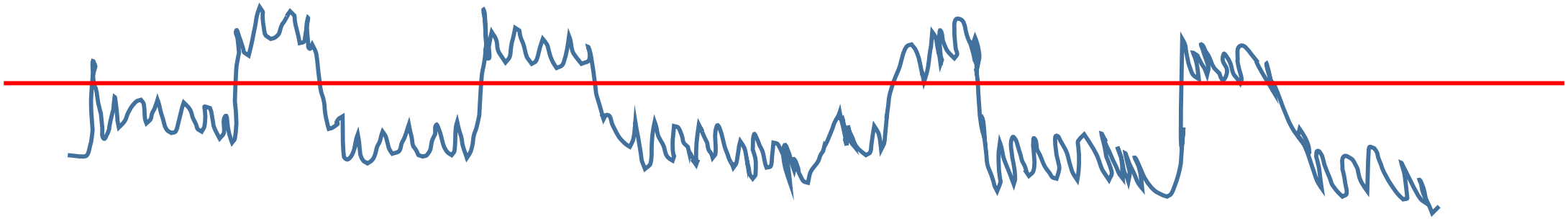
[a] This number does not include research laboratoriess dedicated solely to BCI research.

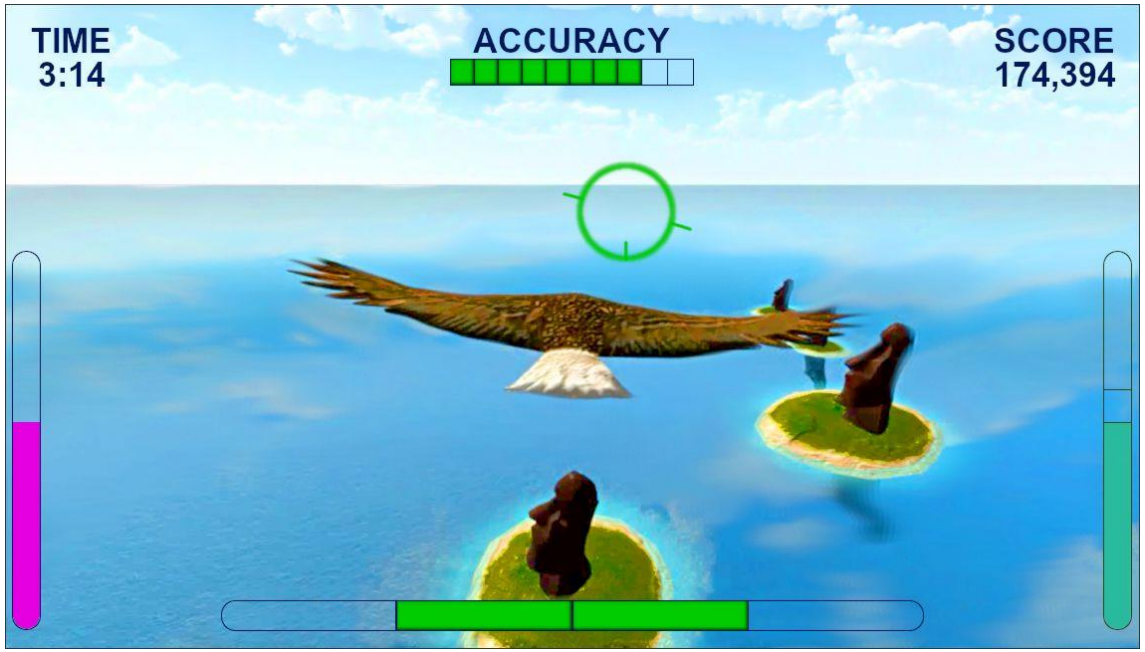
[b] Running costs based on fees charged at the Montreal Neurological Institute in Canada.

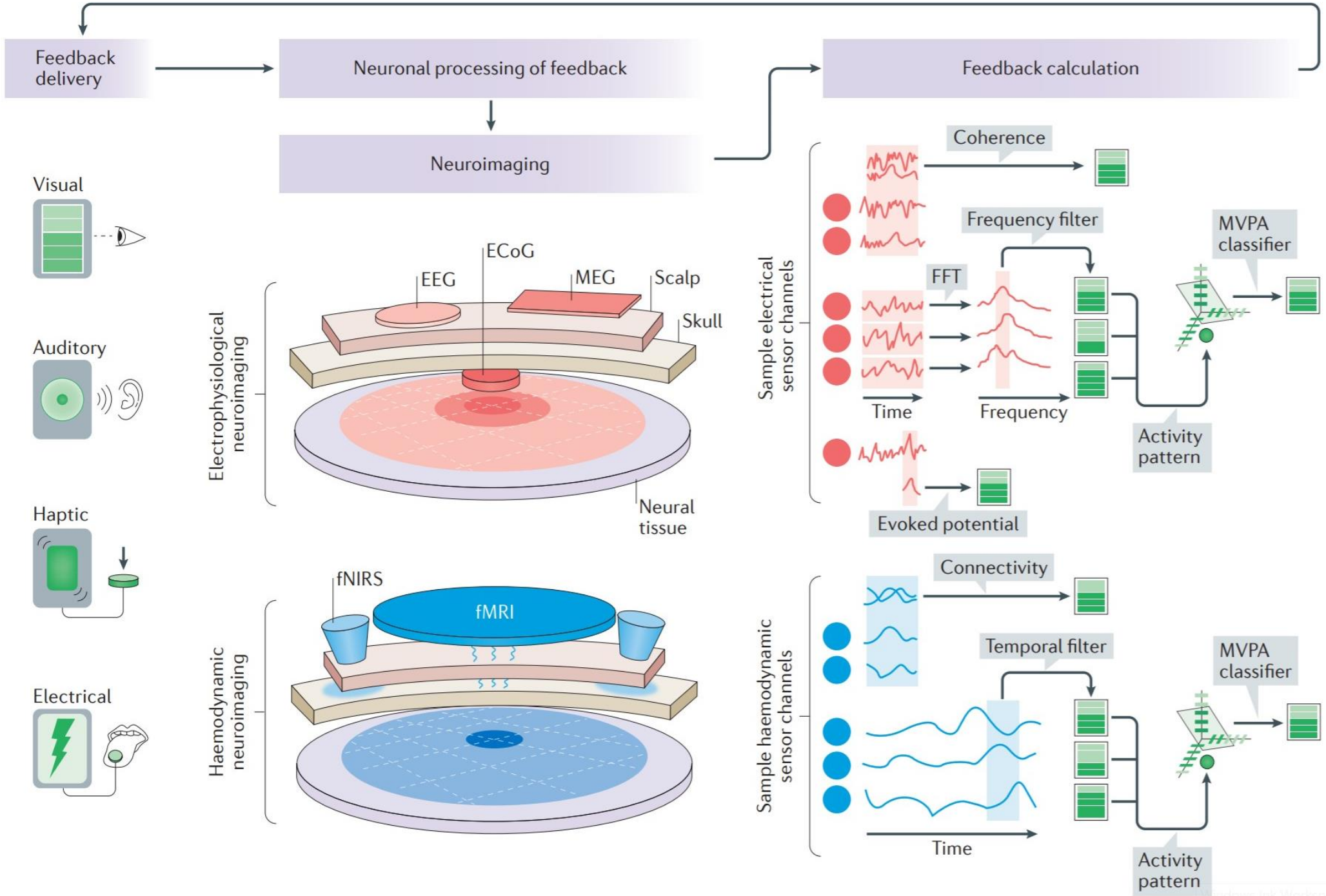
[c] Prices vary between centers. We report a representative price taken from an EEG-nf clinic in Austin, Tex., USA, and one in New York City, N.Y., USA.

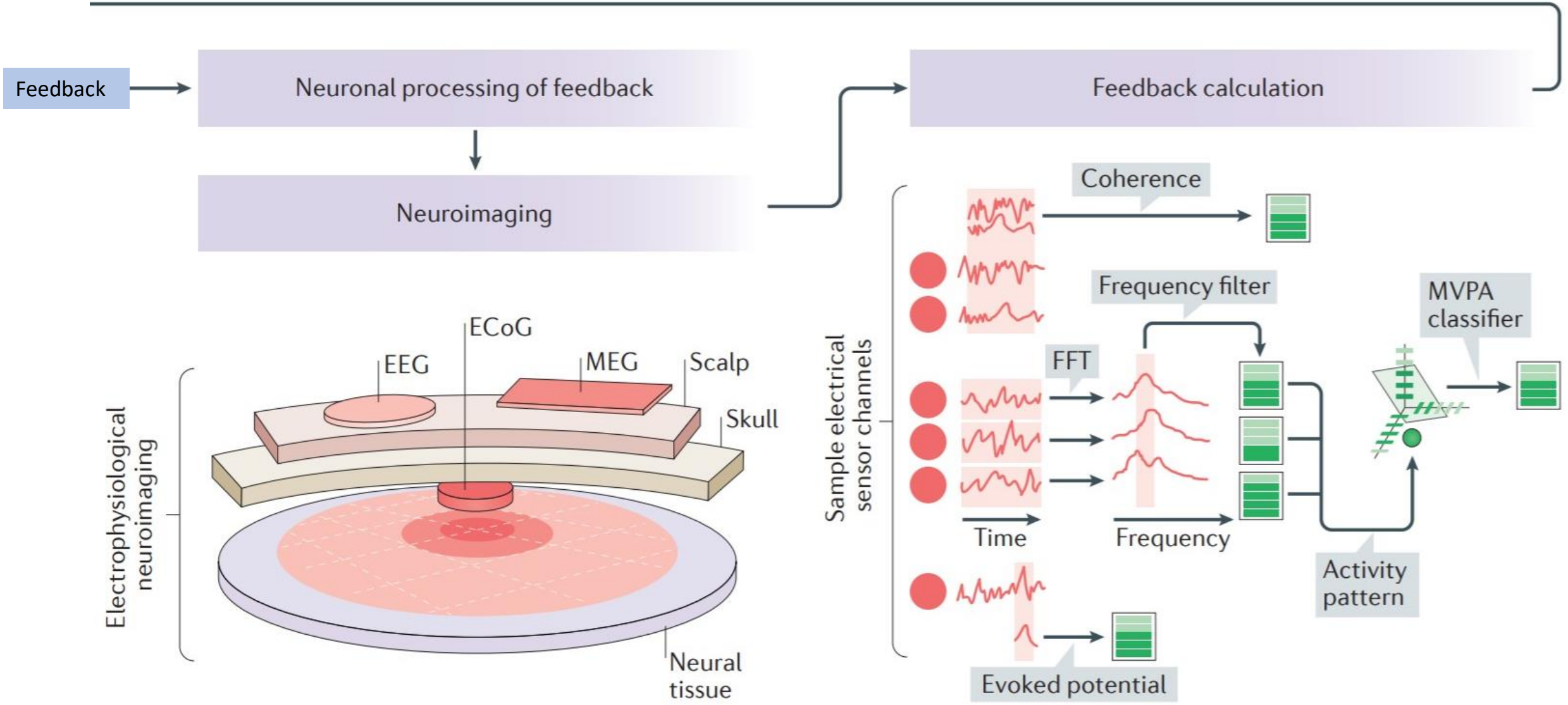
Three main aims of any Neurofeedback modalities

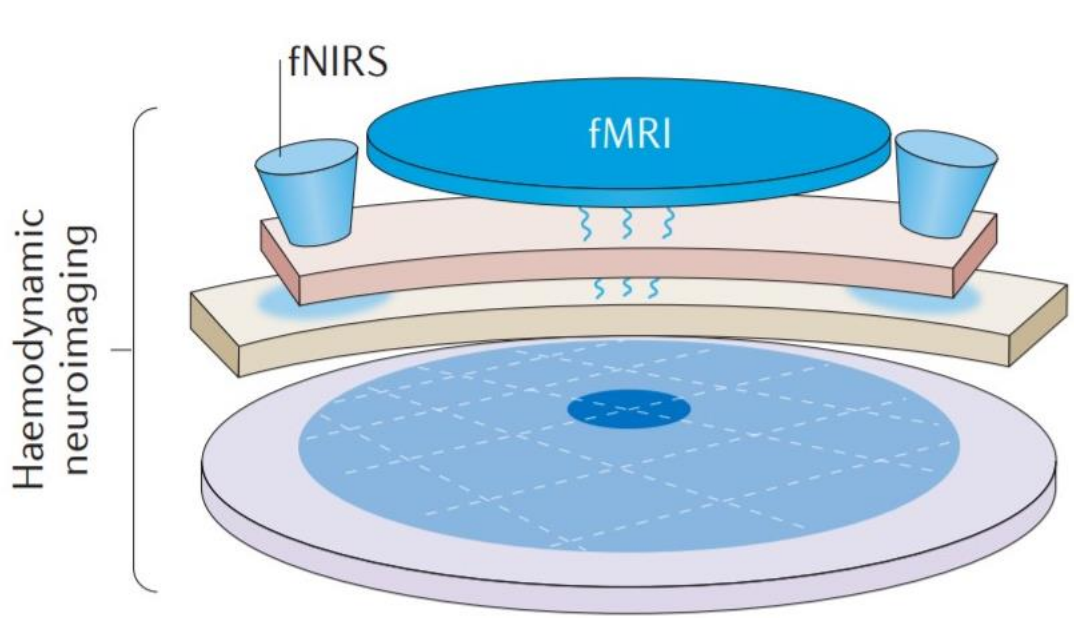
Line graph:
EEG, fMRI, fNIRS, MEG

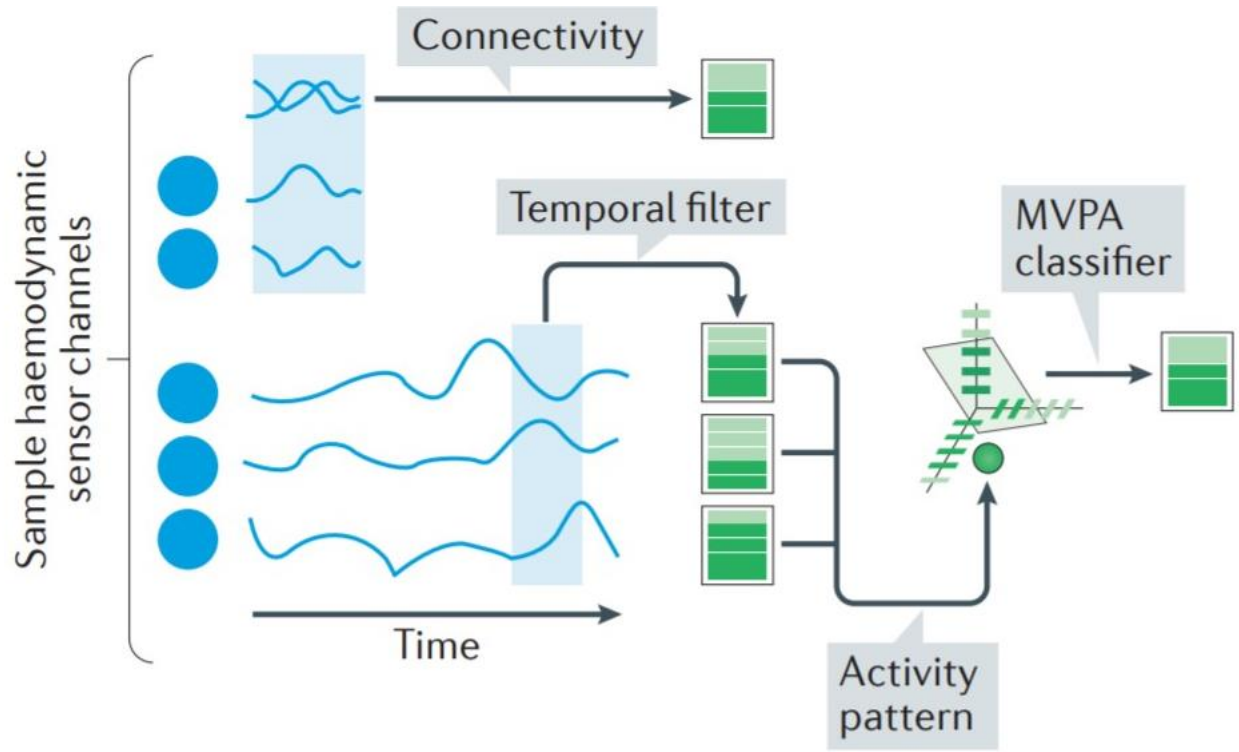


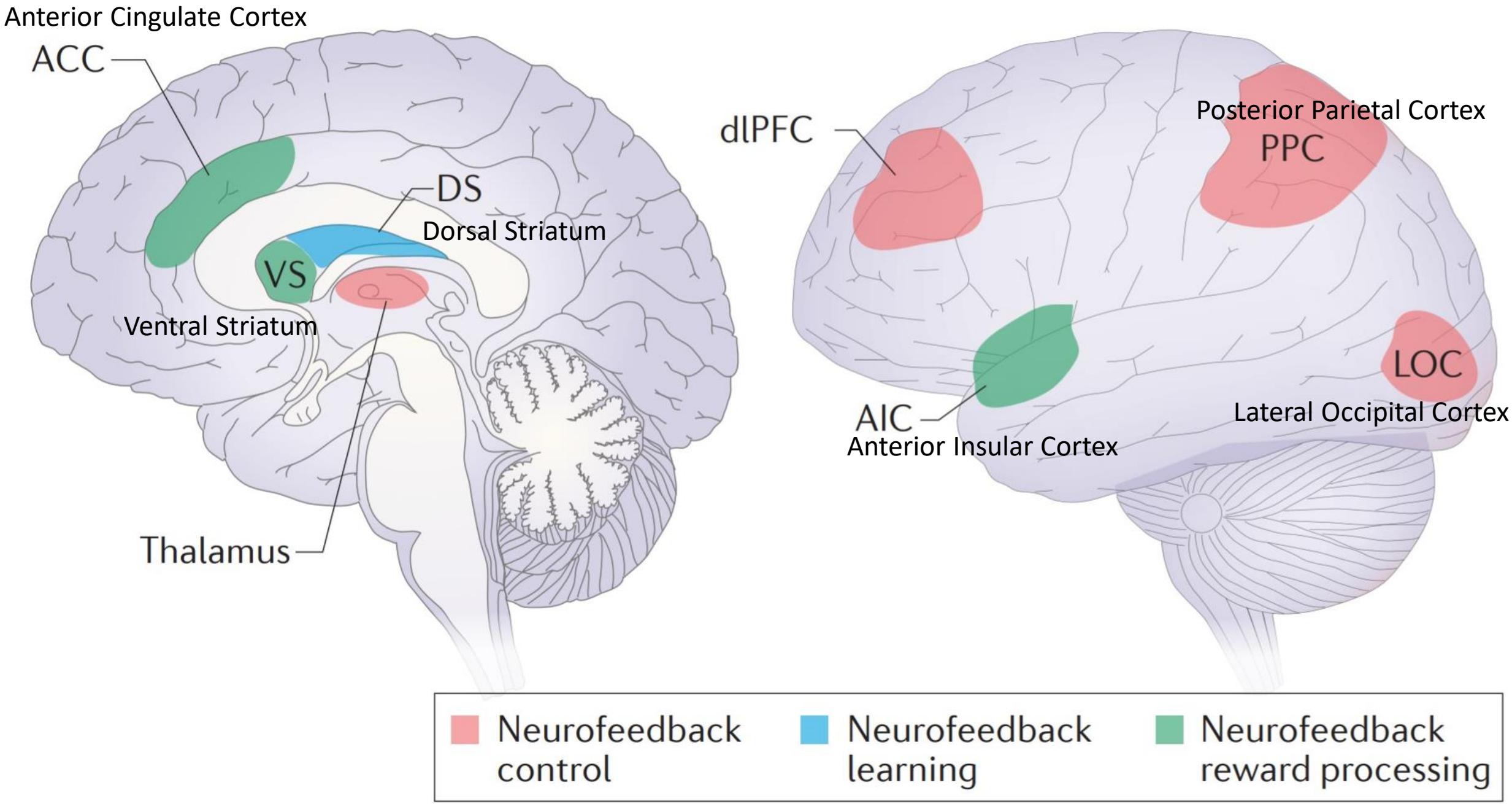



Feedback delivery
Neuronal processing of feedback
Feedback calculation
Neuroimaging
Visual
Auditory
Haptic
Electrical
Electrophysiological neuroimaging
EEG
ECoG
MEG
Scalp
Skull
Neural tissue
Haemodynamic neuroimaging
fNIRS
fMRI
Sample electrical sensor channels
Coherence
Frequency filter
FFT
MVPA classifier
Time
Frequency
Activity pattern
Evoked potential
Sample haemodynamic sensor channels
Connectivity
Temporal filter
MVPA classifier
Time
Activity pattern


Feedback
Neuronal processing of feedback
Neuroimaging
Feedback calculation
Electrophysiological neuroimaging
EEG
ECoG
MEG
Scalp
Skull
Neural tissue
Sample electrical sensor channels
Coherence
Frequency filter
FFT
MVPA classifier
Time
Frequency
Activity pattern
Evoked potential


fNIRS
fMRI
Haemodynamic neuroimaging


Connectivity
Temporal filter
MVPA classifier
Sample haemodynamic sensor channels
Time
Activity pattern


Anterior Cingulate Cortex
ACC
DS
Dorsal Striatum
VS
Ventral Striatum
Thalamus
dlPFC
Posterior Parietal Cortex
PPC
LOC
Lateral Occipital Cortex
AIC
Anterior Insular Cortex
Neurofeedback control
Neurofeedback learning
Neurofeedback reward processing

Conclusion

- The goal of clinical and behavioural neuroscience is to observe and to understand nervous system mechanisms to manipulate behaviour-related neural processes and to restore or enhance function.

- In neurofeedback, brain activation is volitionally regulated through learning; as the activation acts as an independent variable, it allows causal inferences to be made between brain activity and behaviour. The different behavioural changes that have been observed to result from self-manipulation of neural activation indicate that the physiological consequences of neurofeedback may be considered to be a form of endogenous neural stimulation

Conclusion

- We can do only symptom based and routine neurofeedback practice based on new finding in near future

- latest meta-analysis on long-term effects is one of the most promising pieces of evidence we have thus far (Van Doren et al., 2018). Here was found that across studies, clinical benefit from neurofeedback tended to improve further with time e without any sessions during the follow-up period. And, clinical benefit was similar for neurofeedback, when compared to active treatments including medication (where medication was continued during the follow-up period).