



دانشگاه علوم پزشکی و خدمات بهداشتی، درمانی ایران



Introducing neurofeedback & its application in clinical neuroscience

Mohammad Ali NAZARI

Professor, Iran University of Medical Sciences



Neurofeedback

Introduction

History and Trends

Application

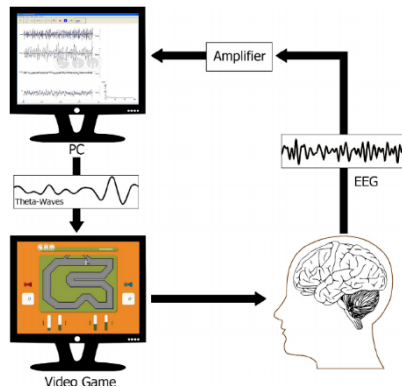
Challenges

efficacy / inefficiency

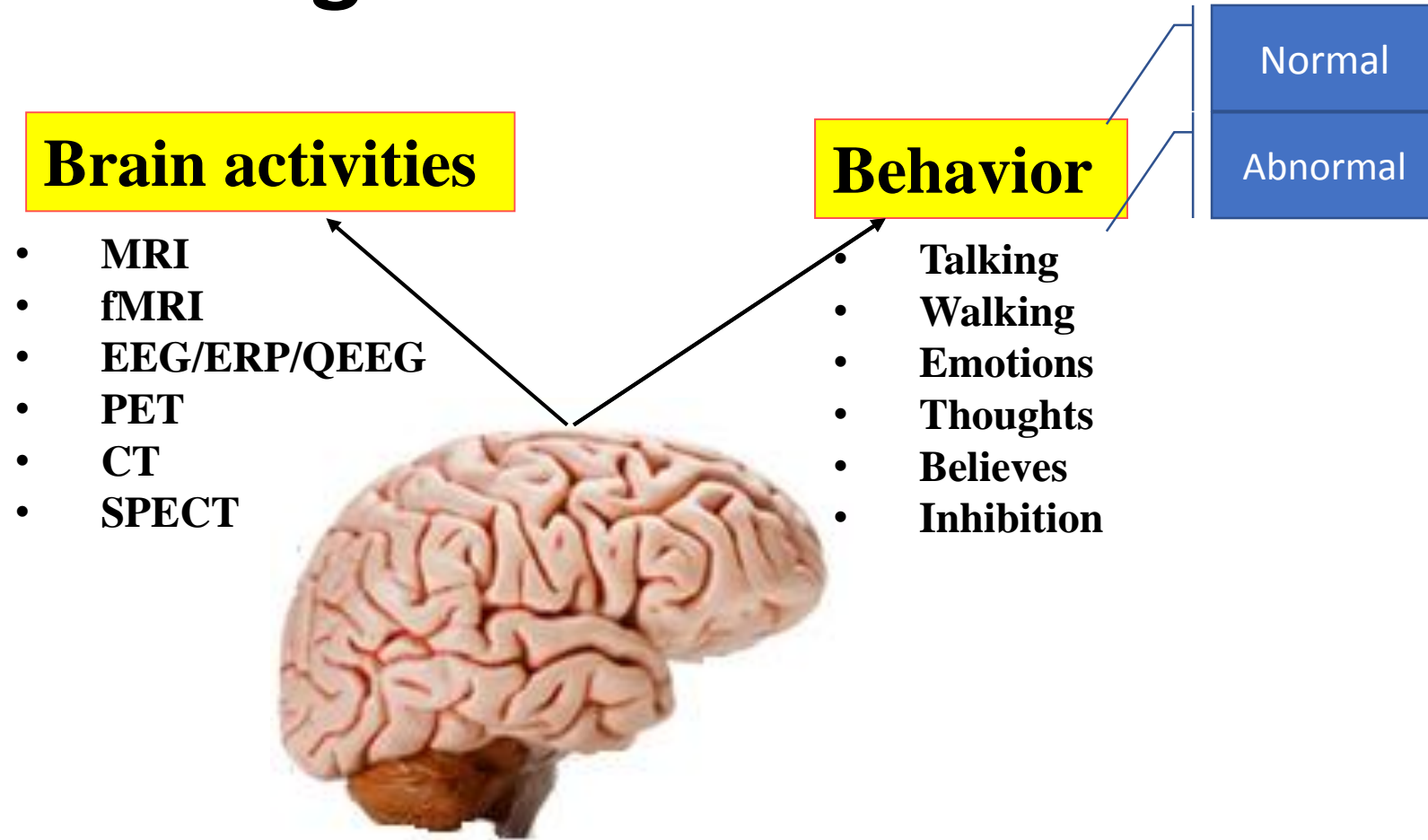
Unknown mechanism

Practical Problem

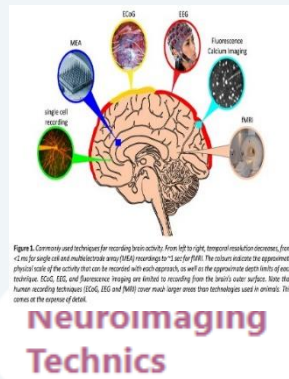
Organizational Problem



Origin of Behavior



EEG and Behavior: correlation



Neuroimaging Technics

cognitive neuroscience

others

EEG

Outside-in approach

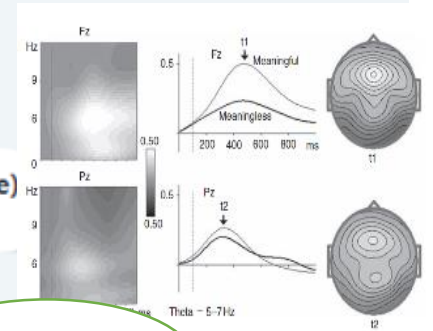
Inside-out approach

ERD/ERS studies

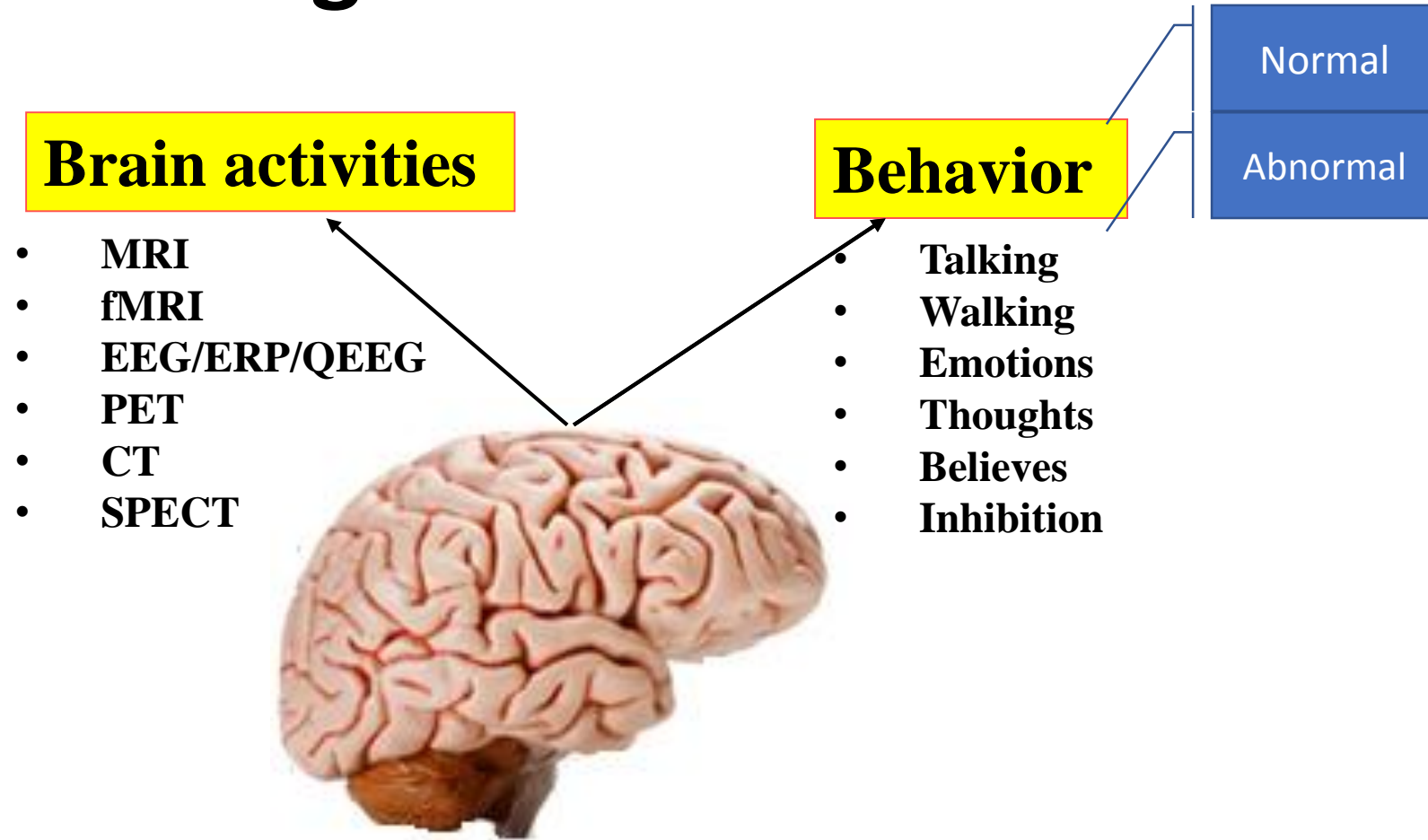
Cognitive processes (Independent Variable)
EEG oscillation (Dependent Variable)

Cognitive
function

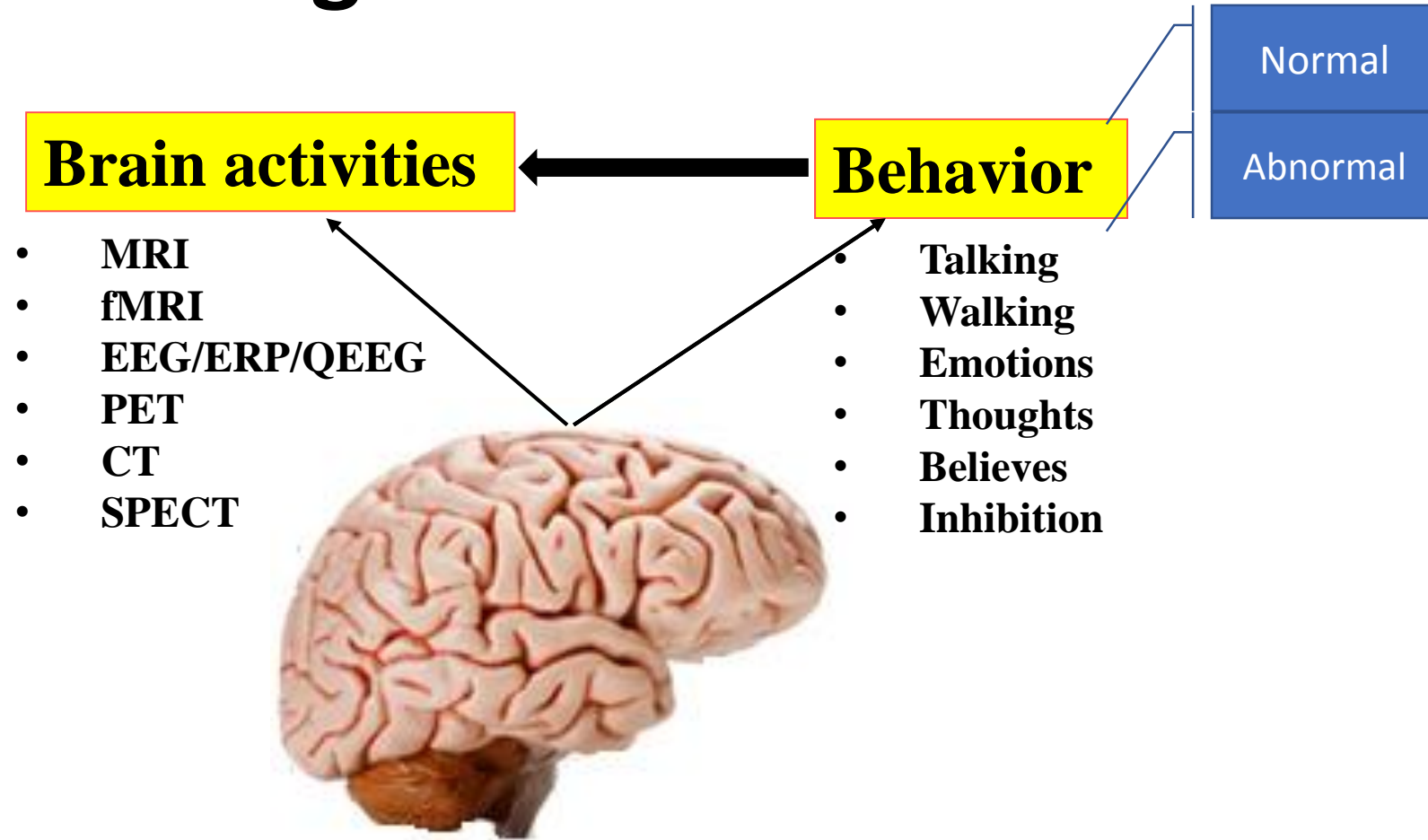
EEG



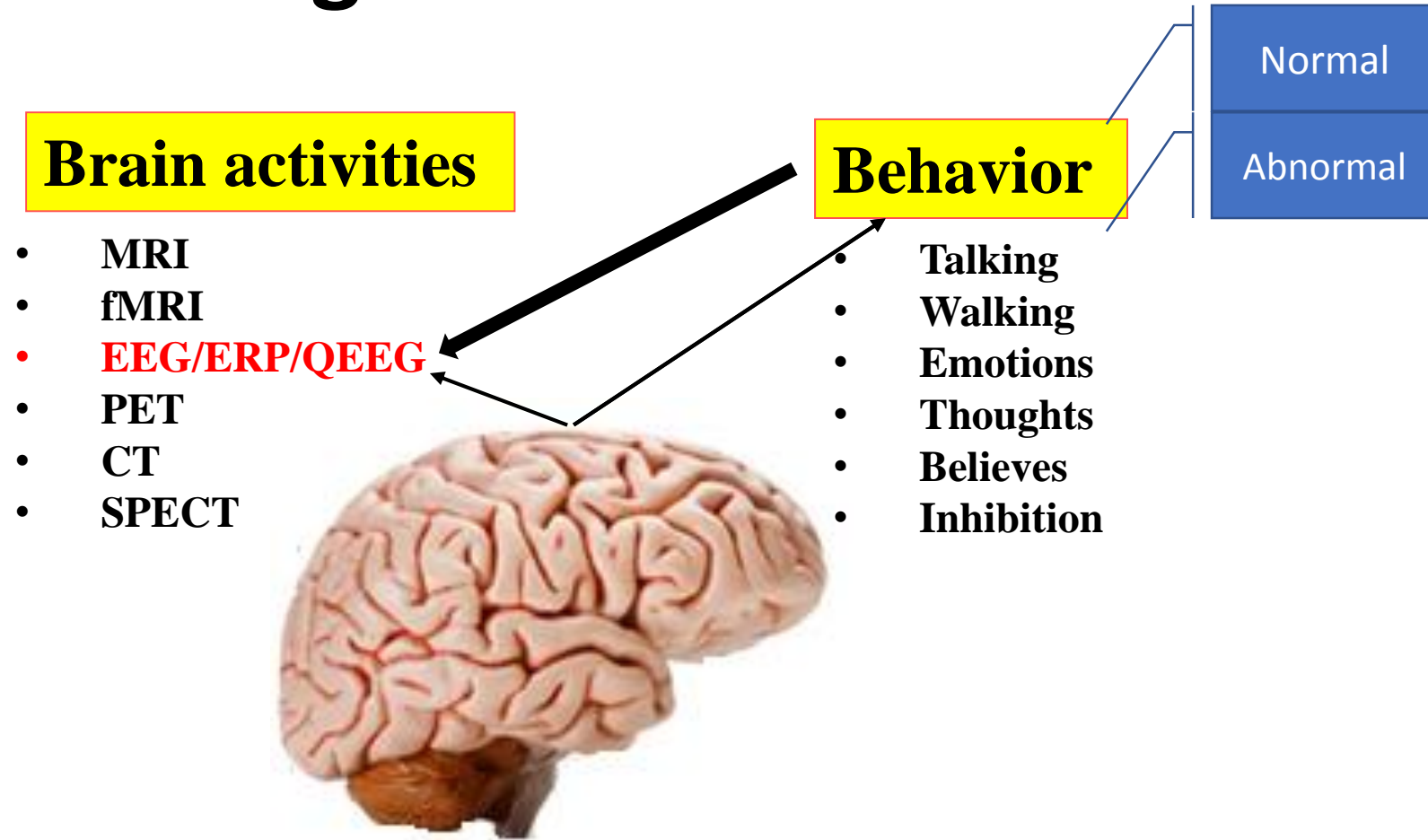
Origin of Behavior



Origin of Behavior



Origin of Behavior



Outside-in: consolidation memory and alpha

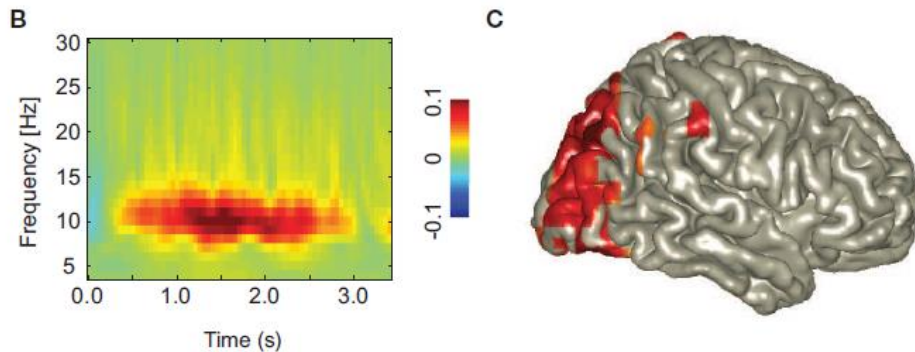


Using brain-computer interfaces and brain-state dependent stimulation as tools in cognitive neuroscience

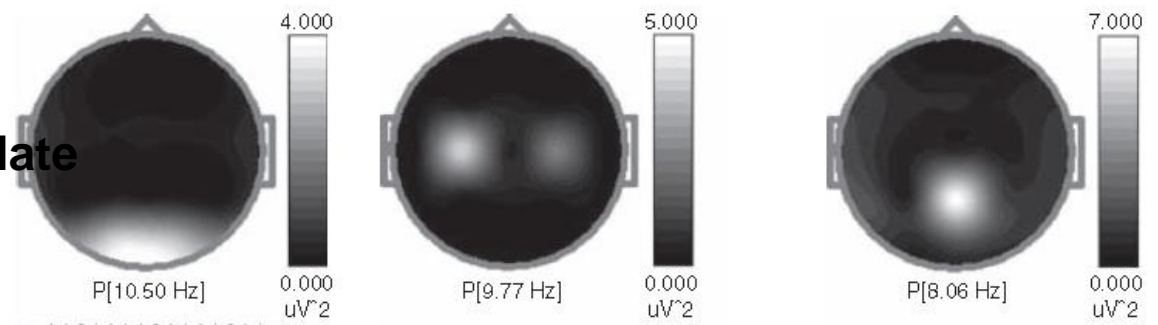
Ole Jensen^{1*}, Ali Bahramisharif^{1,2}, Robert Oostenveld¹, Stefan Klanke¹, Avgis Hadjipapas¹, Yuka O. Okazaki¹ and Marcel A. J. van Gerven^{1,2}

¹ Donders Institute for Brain, Cognition and Behaviour, Radboud University Nijmegen, Netherlands

² Institute for Computing and Information Sciences, Radboud University Nijmegen, Netherlands



An increase in posterior alpha activity correlate with **long-term memory encoding**





Contents lists available at ScienceDirect

International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho



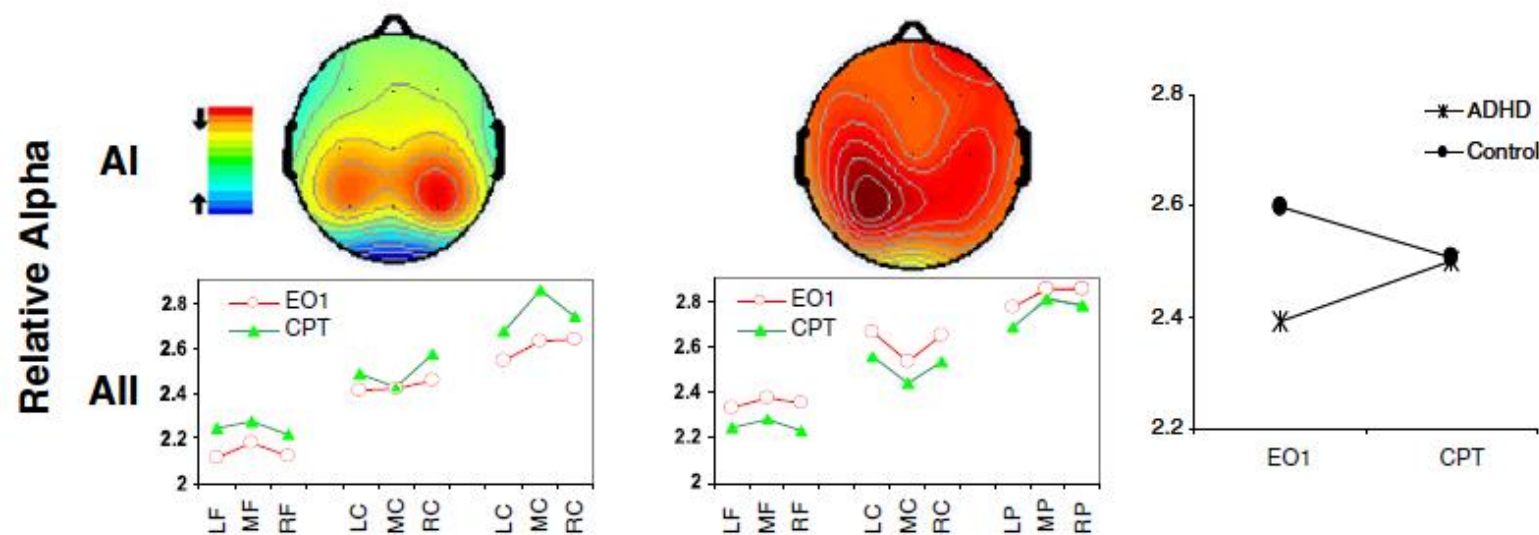
Dynamic changes in quantitative electroencephalogram during continuous performance test in children with attention-deficit/hyperactivity disorder

Mohammad Ali Nazari ^{a,*}, Fabrice Wallois ^b, Ardalan Aarabi ^b, Patrick Berquin ^c

^a Department of Psychology, University of Tabriz, Tabriz, Iran

^b GRAMFC, EA4293, Research Group on Functional Cerebral Multimodal Analysis, Faculty of Medicine, Amiens, France

^c Department of Paediatric Neurology, Lab. Neurosciences Fonctionnelles & Pathologies (CNRS UMR8160), CHU Amiens, Amiens, France



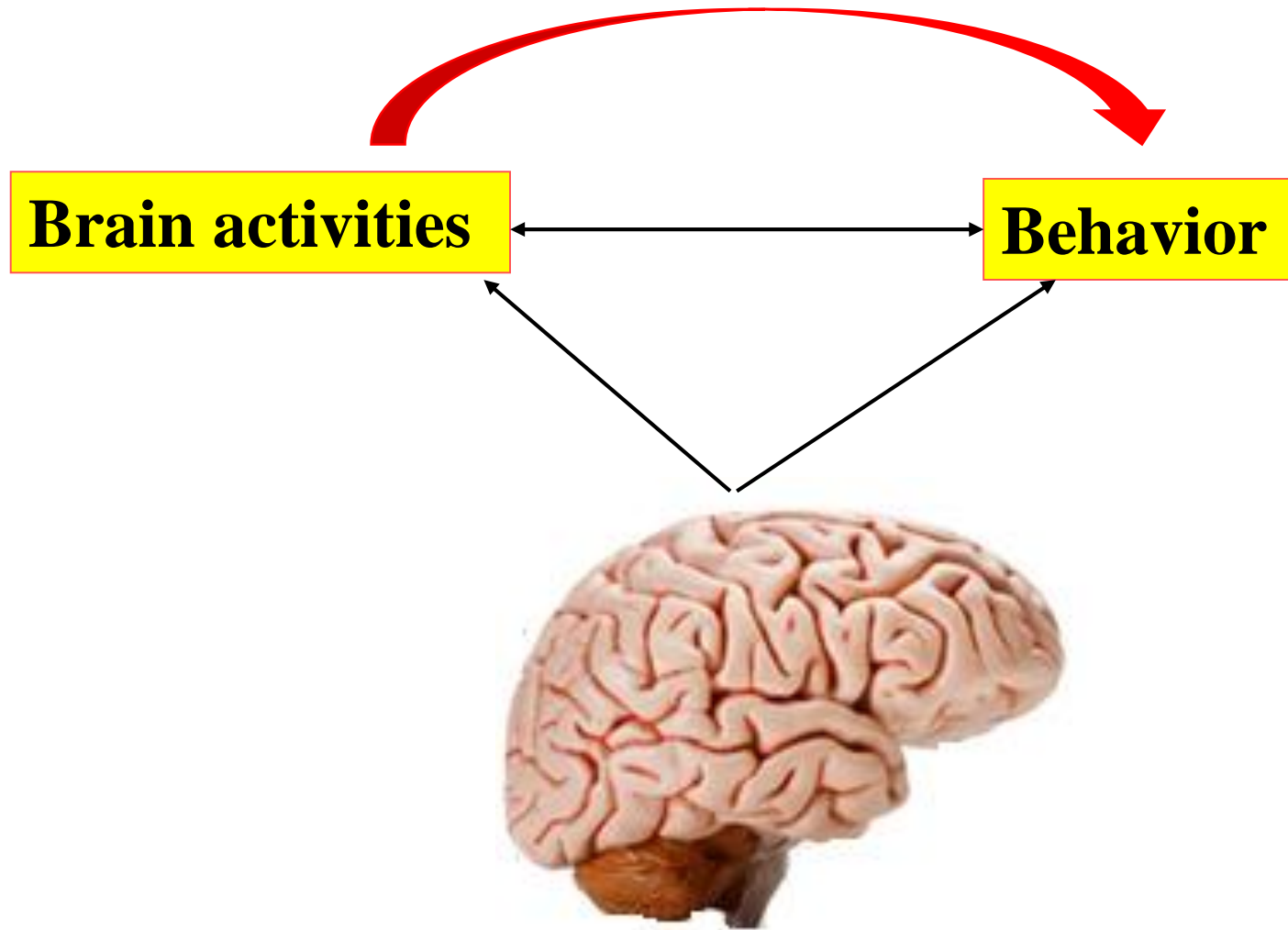
Neural oscillations and cognitive processes

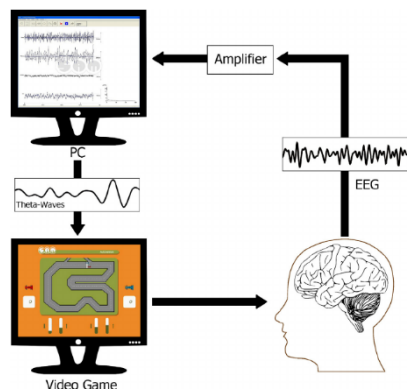
	Delta (1-3 Hz)	Theta (4-7 Hz)	Alpha (8-12 Hz)	Beta (13-30 Hz)	Gamma (30-200 Hz)
Anatomy	frontal and cingulate cortex, thalamus and neocortex	Hippocampus, sensory cortex, frontal midline	thalamus, hippocampus, reticular formation, sensory cortex, prefrontal cortex, occipital cortex	Cortical structures, subthalamic nucleus, basal ganglia and olfactory bulb	Cortical Activation, Olfactory bulb
Cognitive Behavior	inhibitory manner Memory, synaptic plasticity	GO/NOGO memory processes ,Top-down control, synaptic plasticity, Learning, Attention anxiety,	inhibition, selective attention, consciousness Memory, Top down control, Motor planning, creativity	Sensory gating, attention, motor control	Perception, attention, memory, consciousness, synaptic plasticity



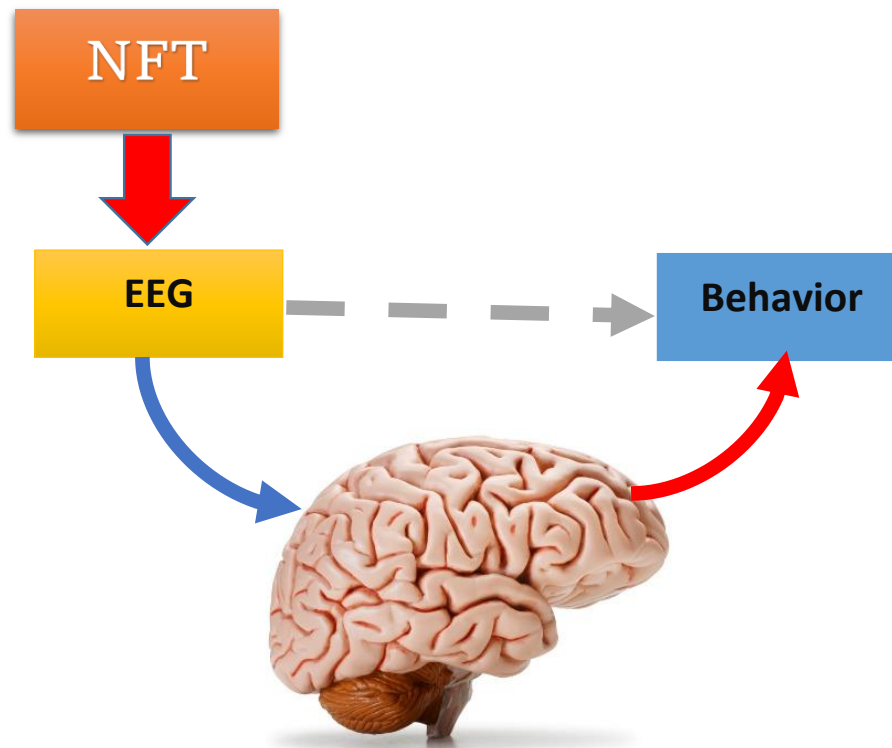
mapping of brain oscillations to cognitive functions is **not possible**

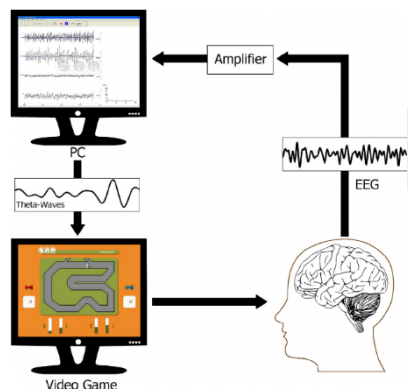
From EEG to Behavior



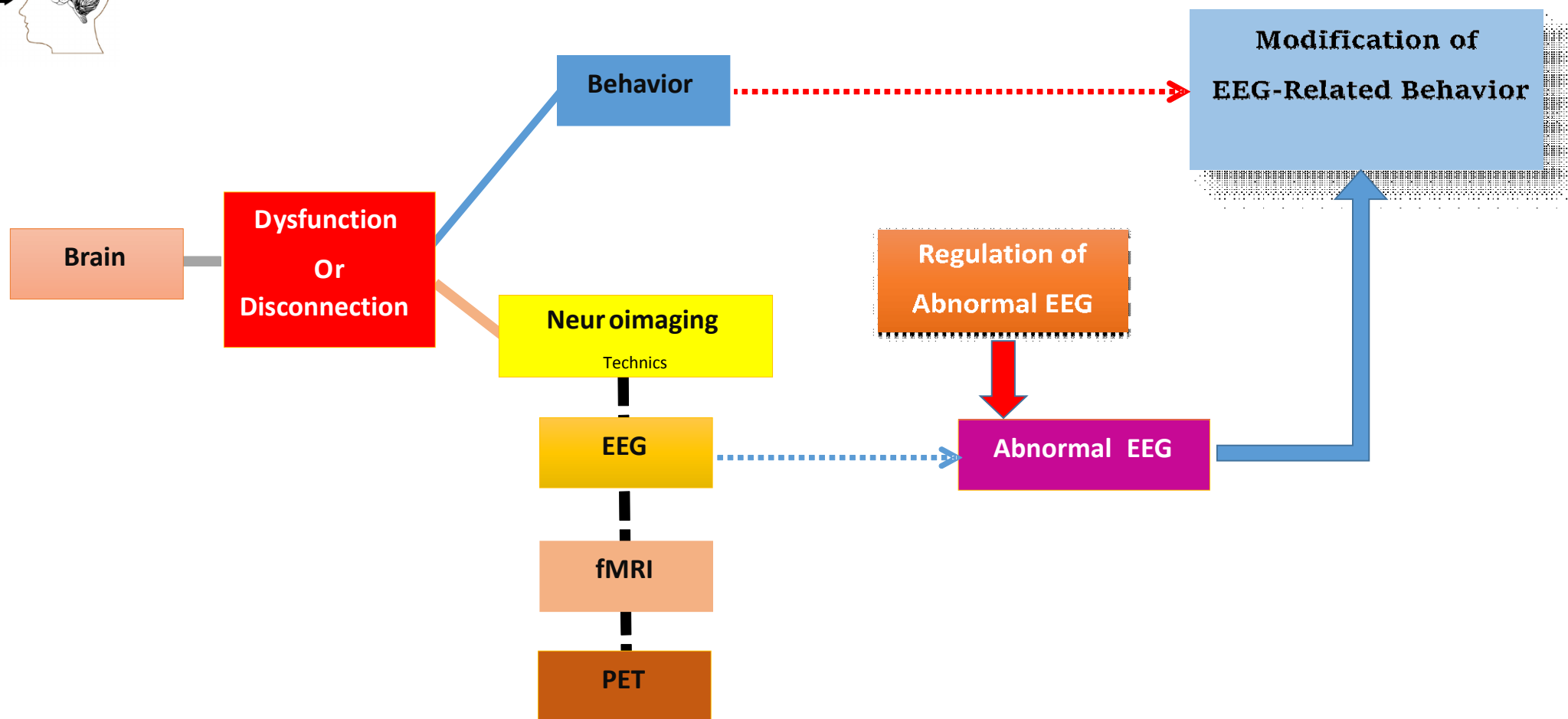


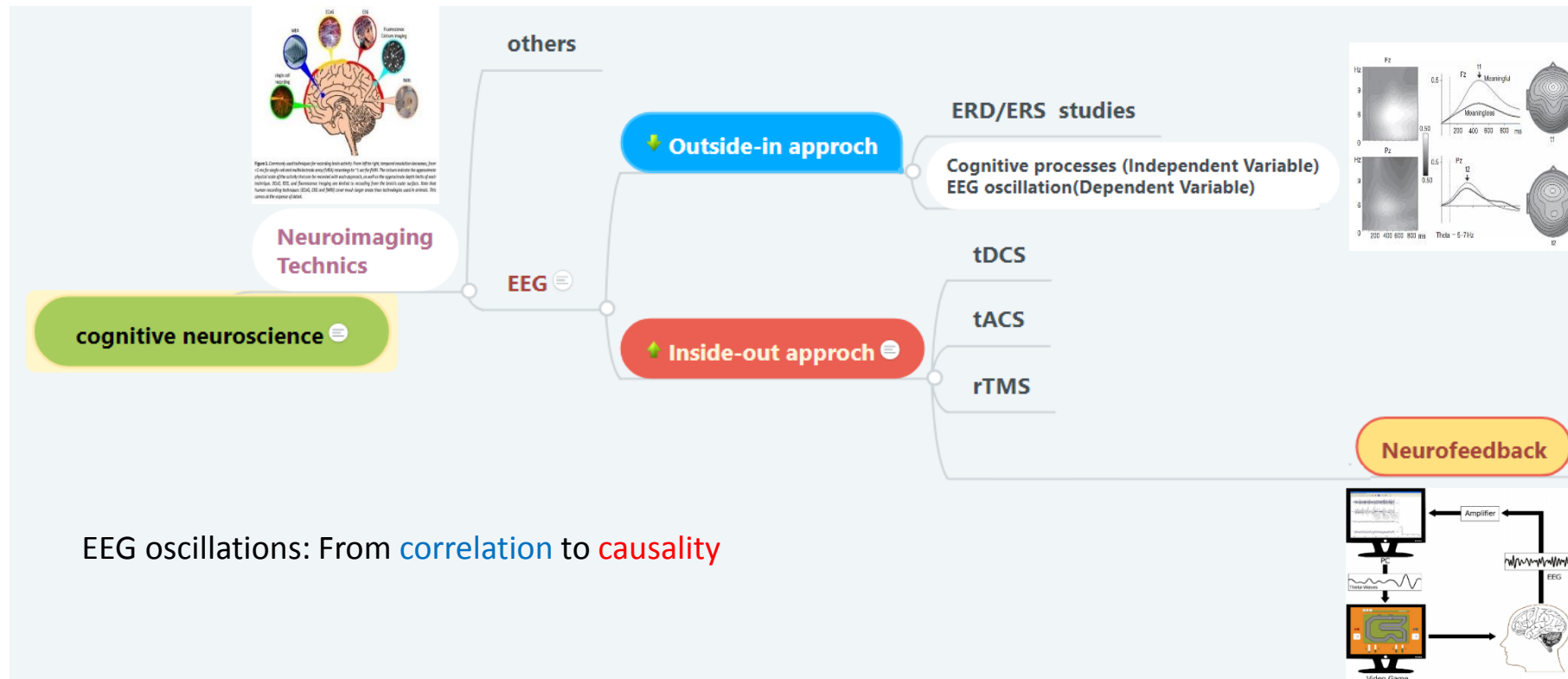
Introduction





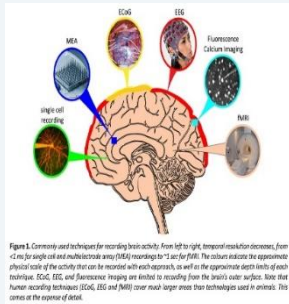
Introduction





Herrmann, Christoph S., Strüüber, Daniel, Helfrich, Randolph F., Engel, Andreas K., EEG oscillations: From correlation to causality, International Journal of Psychophysiology (2015), doi: 10.1016/j.ijpsycho.2015.02.003

Modulation of brain oscillations



Neuroimaging
Technics

cognitive neuroscience

Why NFB?

- ✓ Direct control of brain oscillations
- ✓ Safety
- ✓ Long term stability
- ✓ Produce changes under physiologically conditions
- ✓ Self organization
- ✓ Minimize treatment tolerance
- ✓ Its based on: Brain obey homeostasis

others

EEG

Outside-in approach

ERD/ERS studies

Cognitive processes (Independent Variable)
EEG oscillation (Dependent Variable)

tDCS

tACS

rTMS

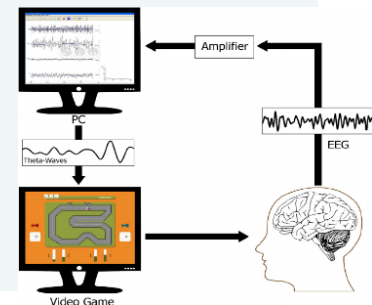
Inside-out approach

EEG oscillation (independent Variable) Cognitive
Process (Dependent variable)

Neurofeedback

EEG

Cognitive
Process

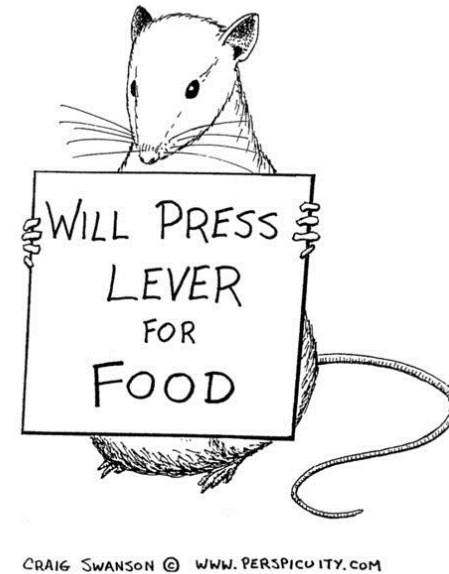
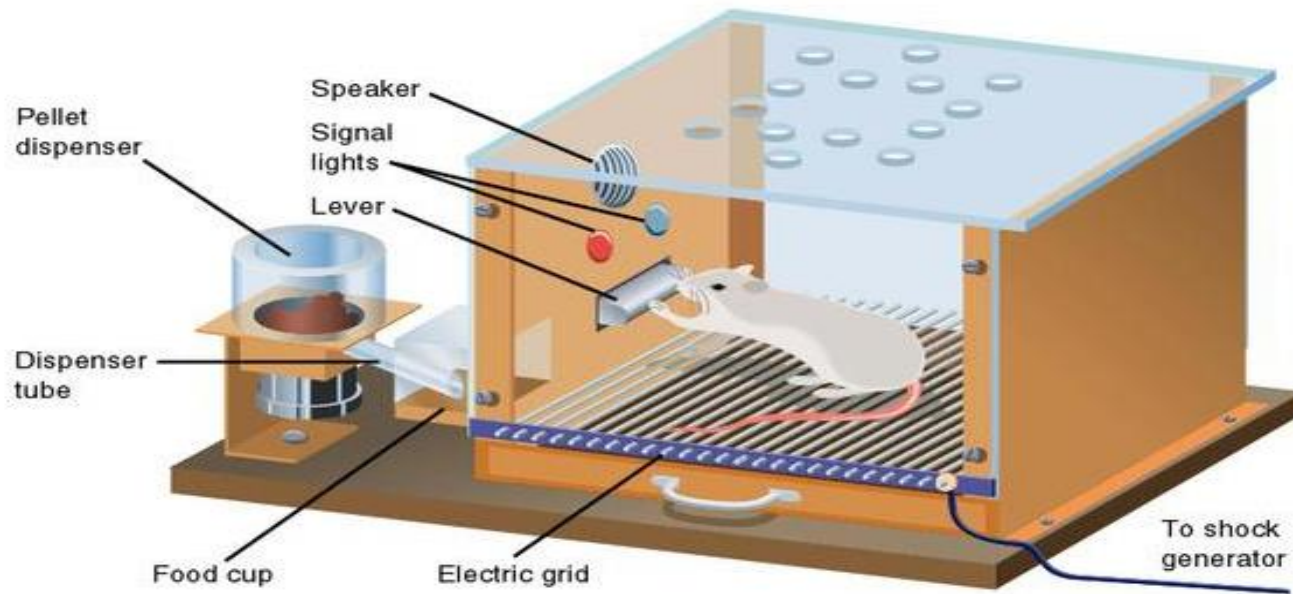


Tuning pathological brain oscillations with neurofeedback: a system neuroscience framework, Tomas Roes 2014

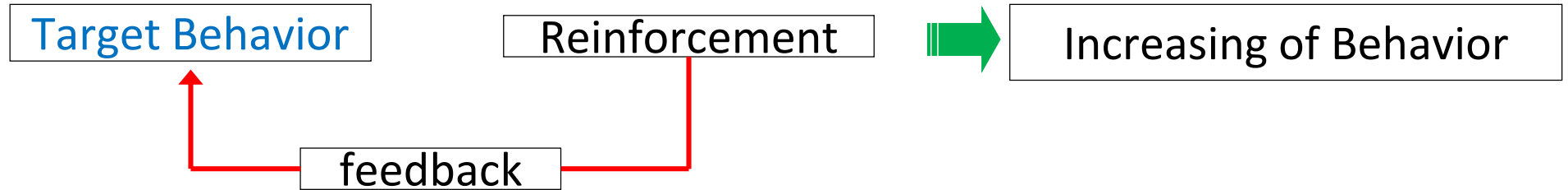
NFT leads to improved
brain self-regulation



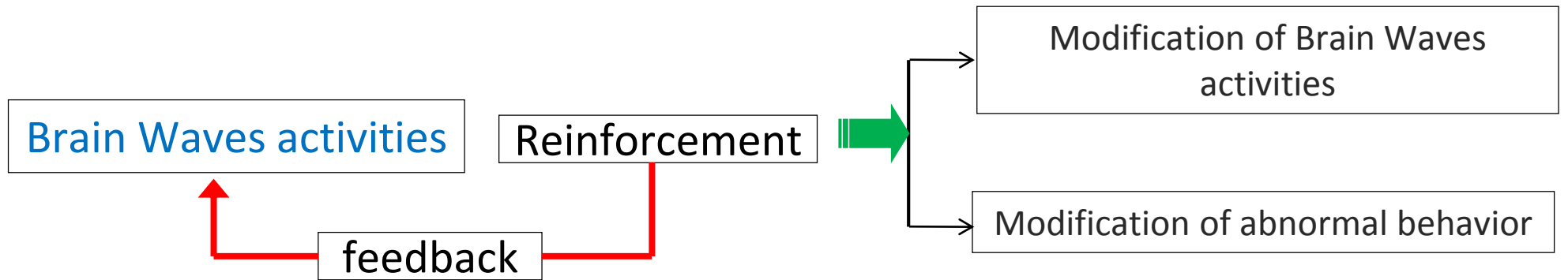
Learning Psychology: Based on Operant Conditioning

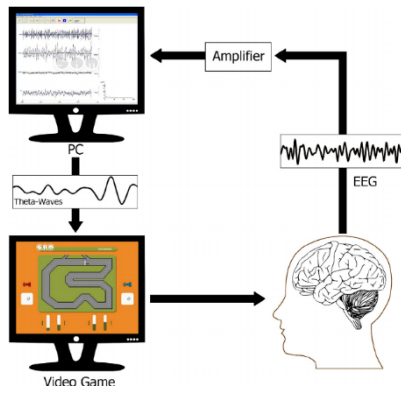


Operant Conditioning

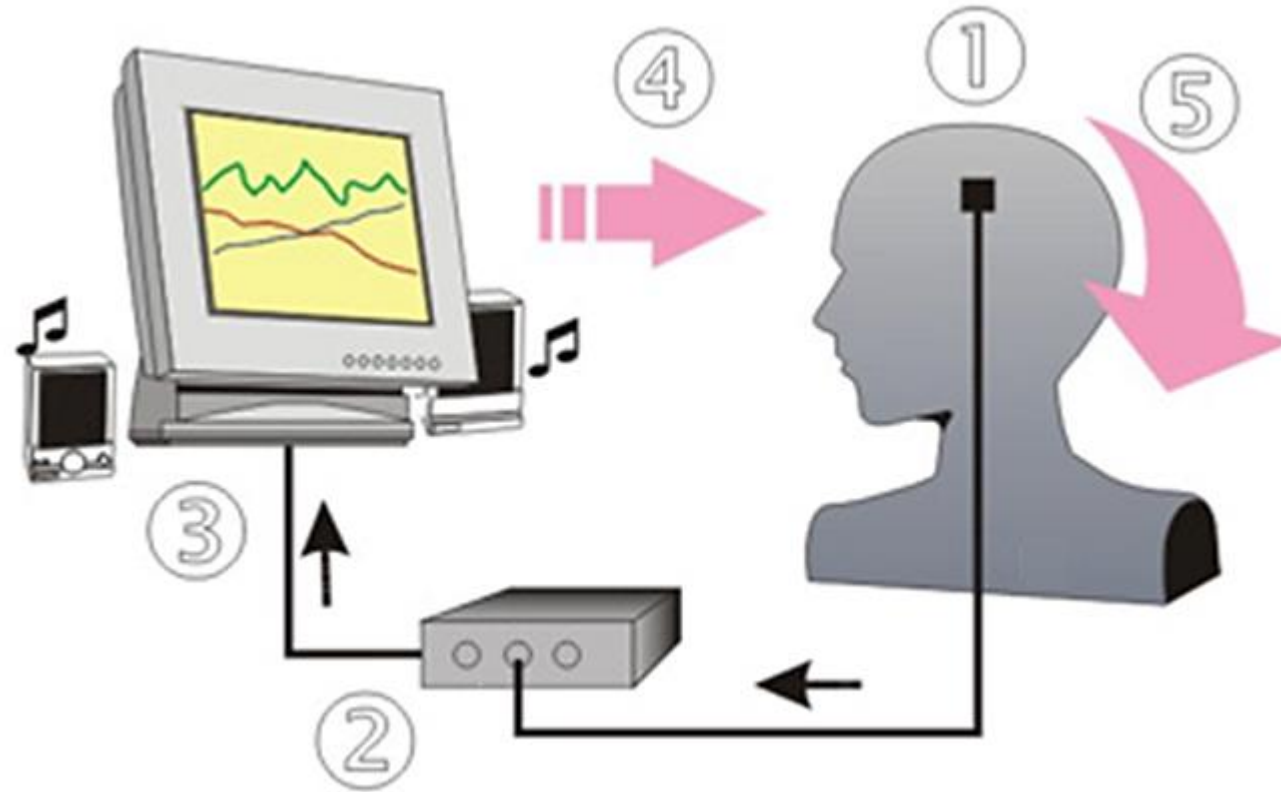


Neurofeedback





Introduction



Nazari, M.A. (2012). EEG findings in ADHD and the application of EEG biofeedback in treatment of ADHD. Norvilitis, J.M (ed.). Current Directions in ADHD and Its Treatment, InTech: Croatia.



BRAIN WAVE FREQUENCIES

- **Delta (1-4 Hz)**
- **Theta (4-8 Hz)**
- **Alpha (8-12 Hz)**
- **Beta (12-36 Hz)**
- **Gamma (36+ Hz)**



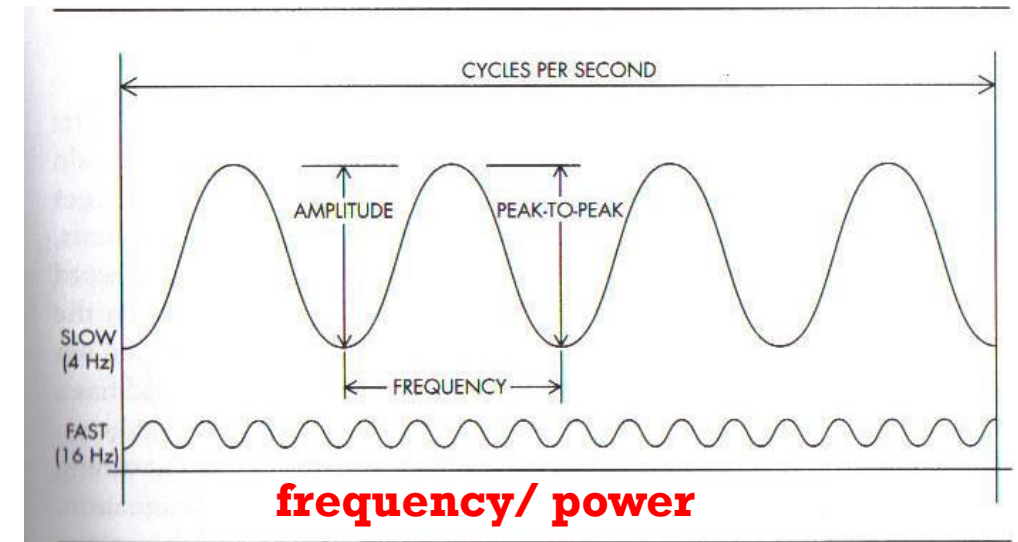
Types of Neurofeedback

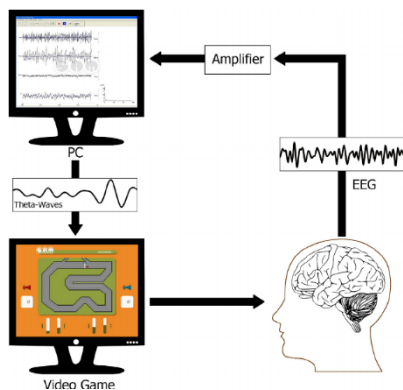
Methodological Note: Neurofeedback: A Comprehensive Review on System Design, Methodology and Clinical Applications



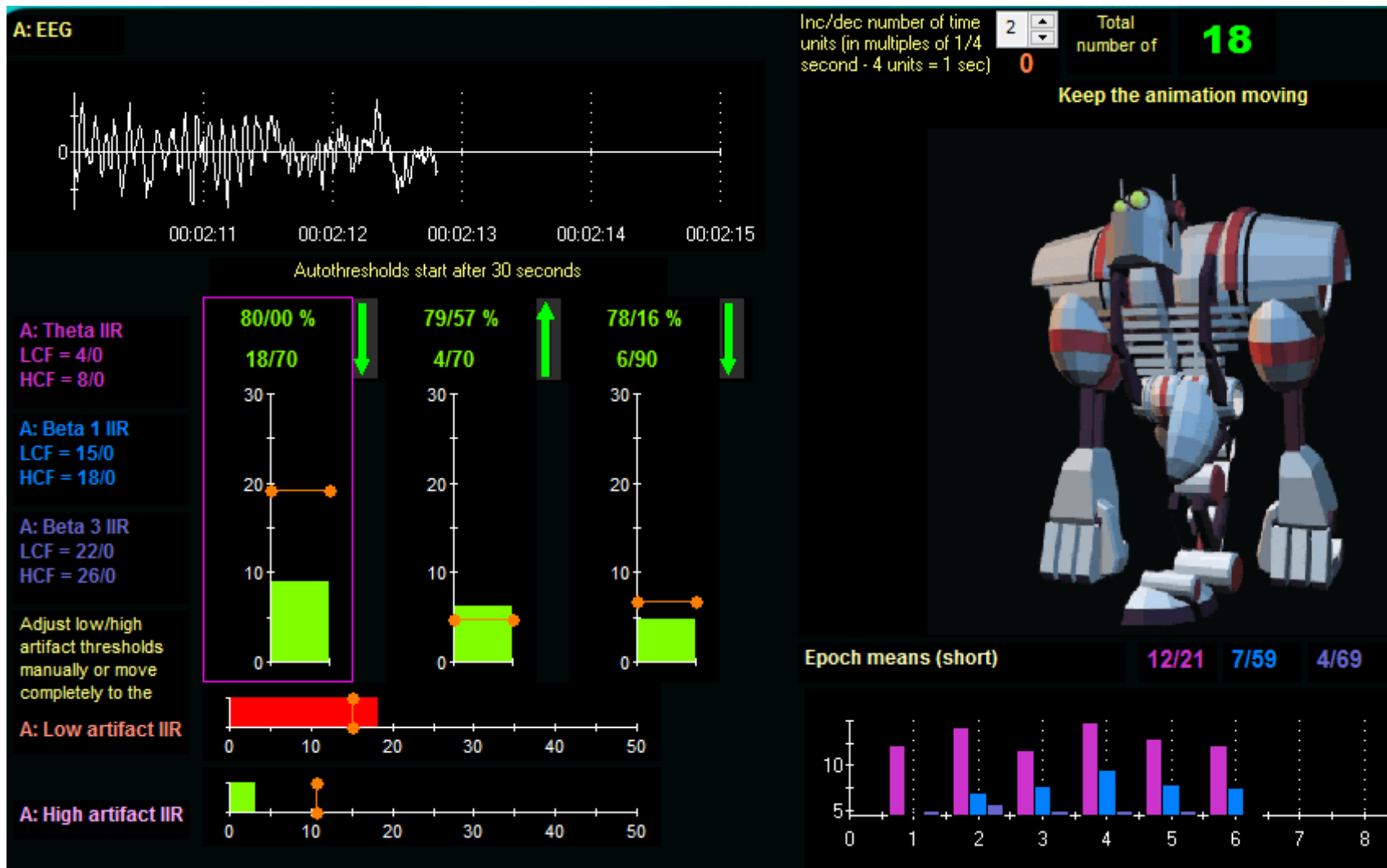
Hengameh Marzban¹, Hamid Reza Marateb¹, Marjan Mansourian^{2*}

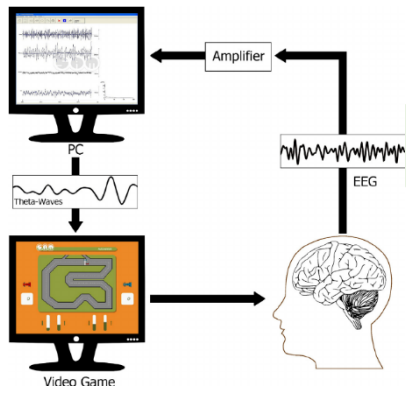
WHAT IS MODULATED IN EEG-NFT?



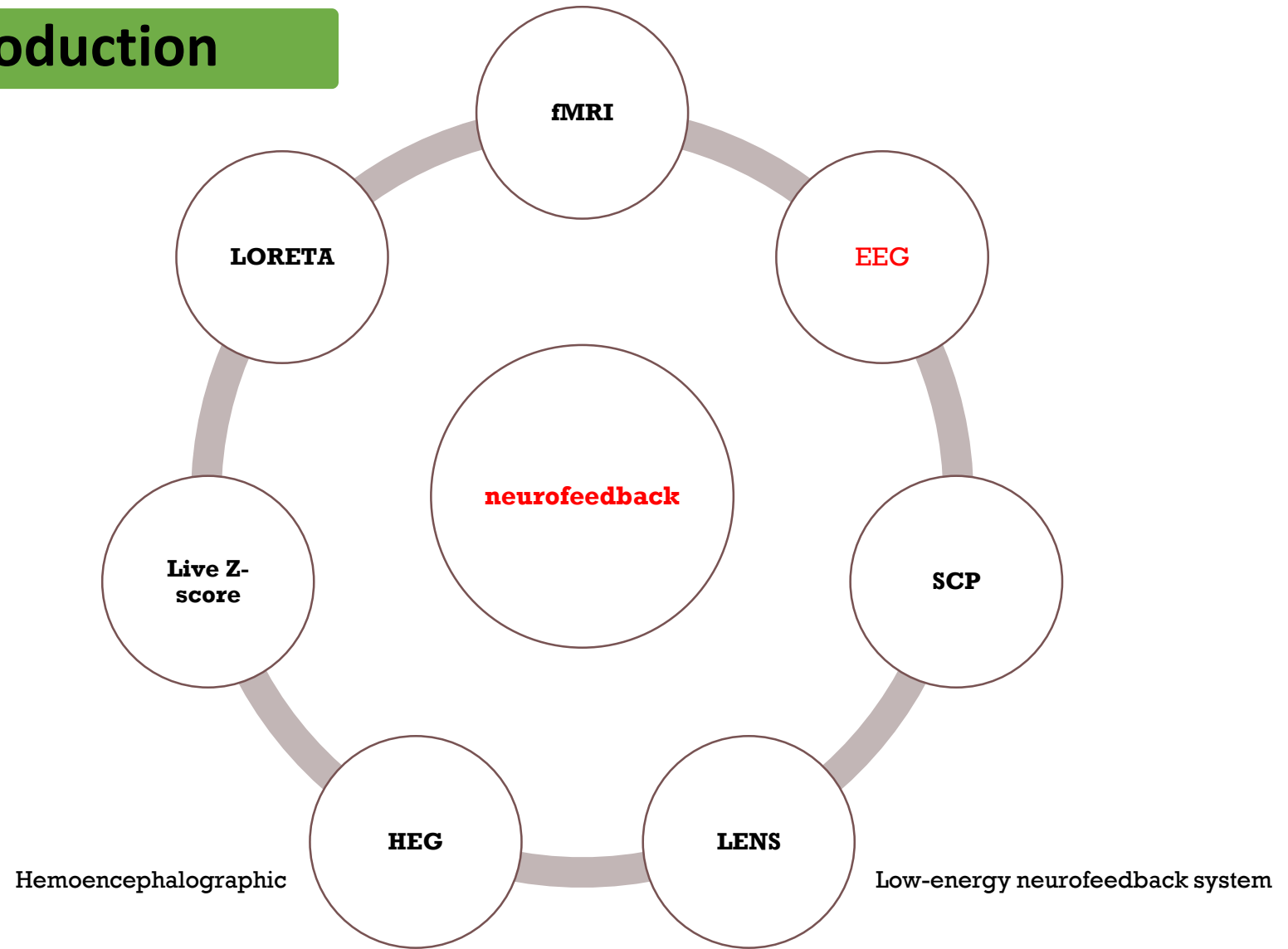


Introduction



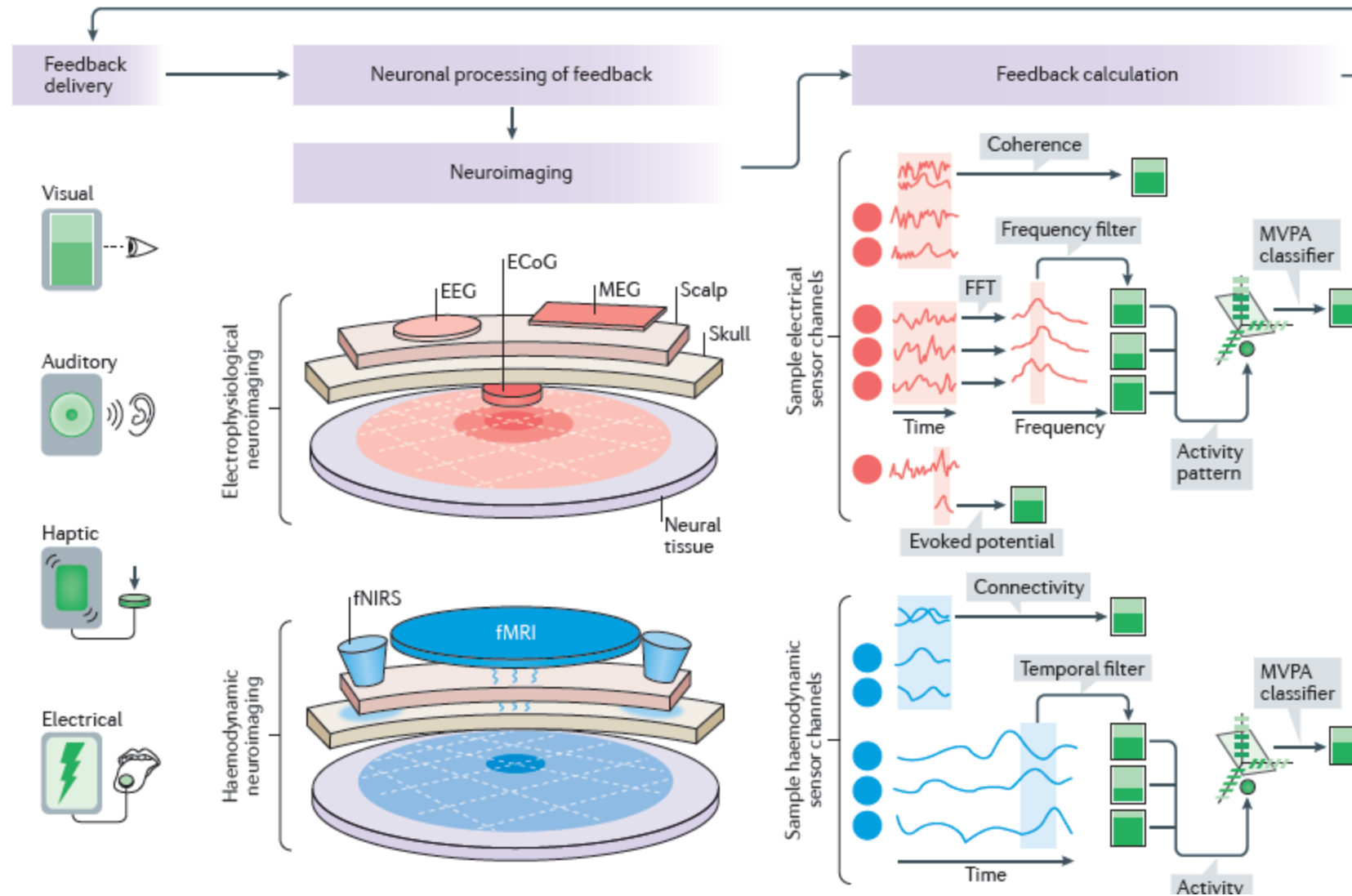


Introduction



Types of Neurofeedback





Sitaram et al. (2016). *Closed-loop brain training: the science of neurofeedback*.
 Nature reviews Neuroscience, 2016



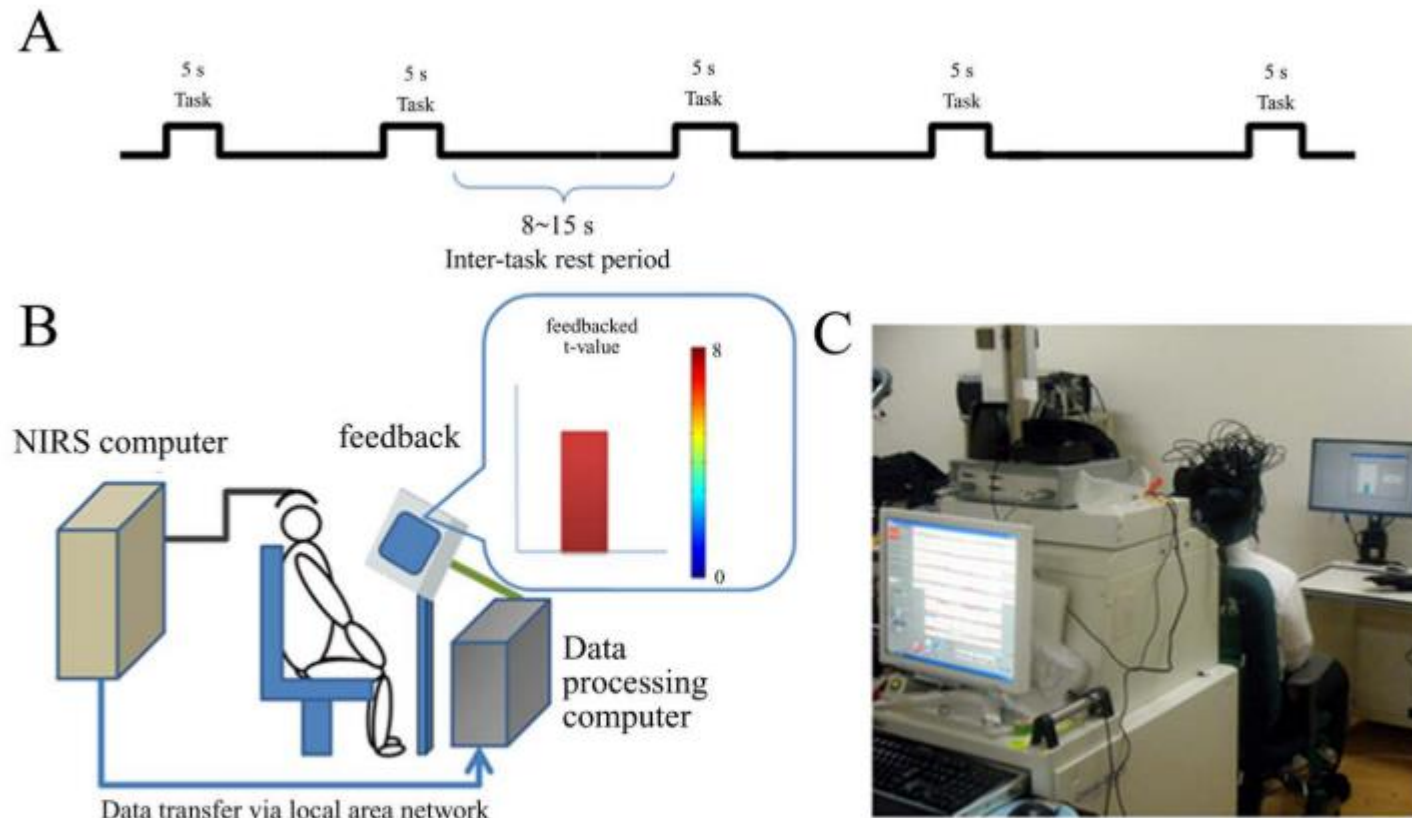


Figure 1. Configuration and testing of the neurofeedback system using NIRS. *A*, Representation of time course of the experiment. Subjects were asked to perform 15 repetitions of a 5-s task with randomized inter-task rest periods between 8–15 s. The total length of one experimental session was no longer than 250 s. *B*, Schematic figure of the NIRS-mediated neurofeedback system. Task-related cortical hemoglobin signal changes were transferred to a data-processing computer, and the evaluated cortical activation was visually fed back in real-time. Cortical activation was represented by bar height and color. *C*, The NIRS-mediated neurofeedback system in use. Subjects were seated in an armchair, and the heads were fixed to the headrest to avoid excessive head movement during experimentation.
doi:10.1371/journal.pone.0032234.g001

Mihara M, Miyai I, Hattori N, Hatakenaka M, Yagura H, Kawano T, et al. (2012) Neurofeedback Using Real-Time Near-Infrared Spectroscopy Enhances Motor Imagery Related Cortical Activation. PLoS ONE 7(3): e32234. Masahito Mihara et al. 2012

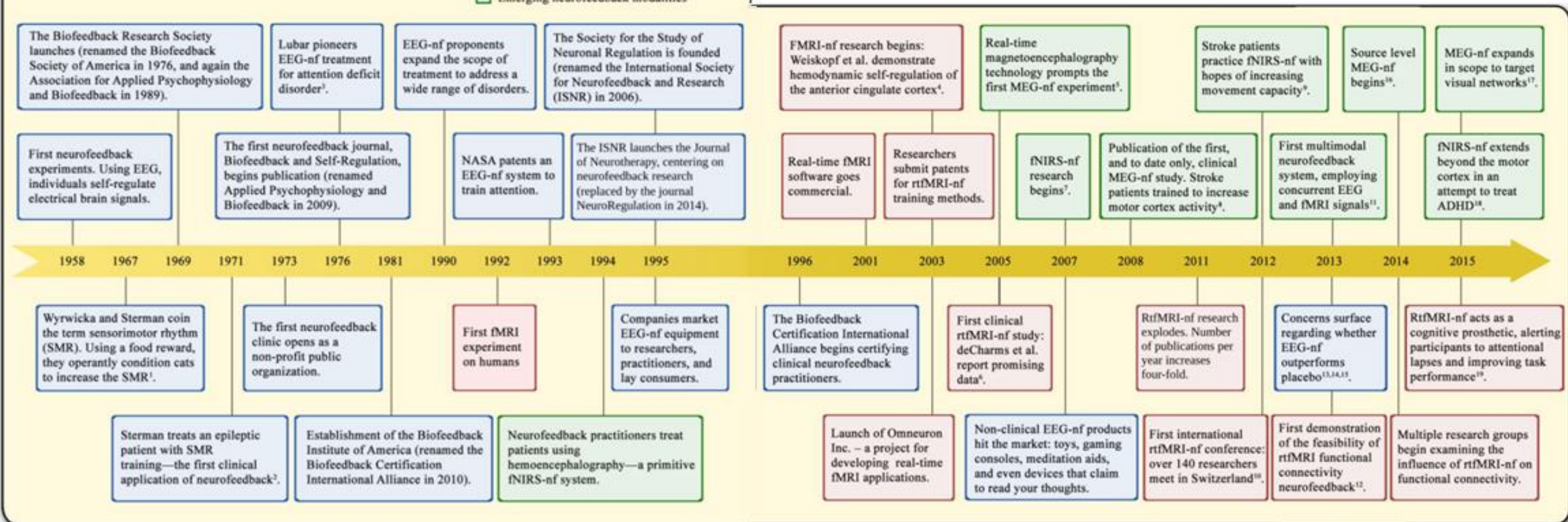


History of Neurofeedback

Nearly six decades of neurofeedback

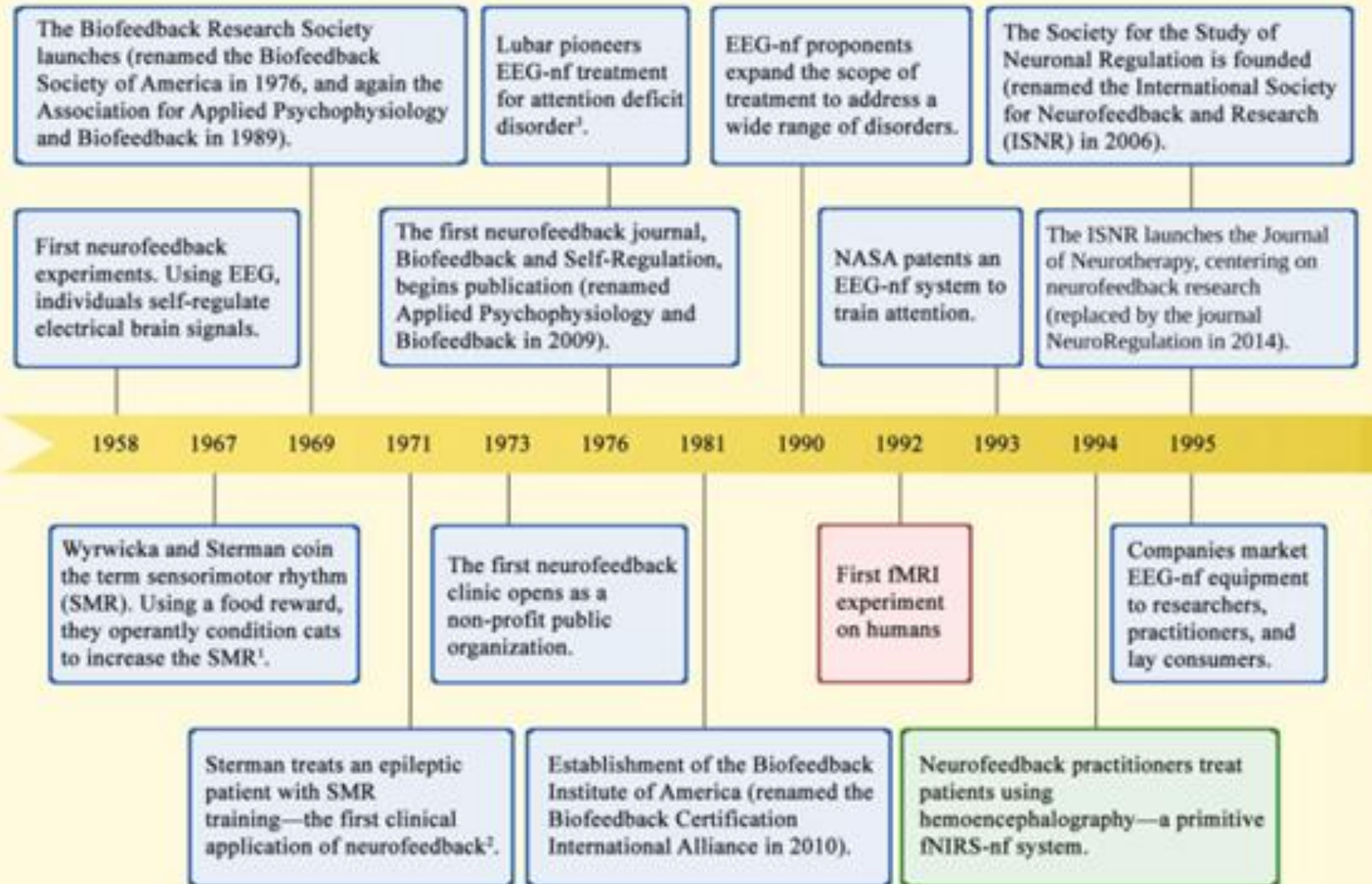
■ EEG-nf
■ fMRI-nf
■ Emerging neurofeedback modalities

Thibault, R. T., Lifshitz, M. and Raz, A. (2016) 'The self-regulating brain and neurofeedback: Experimental science and clinical promise', *Cortex*, 74, pp. 247–261. doi: 10.1016/j.cortex.2015.10.024.

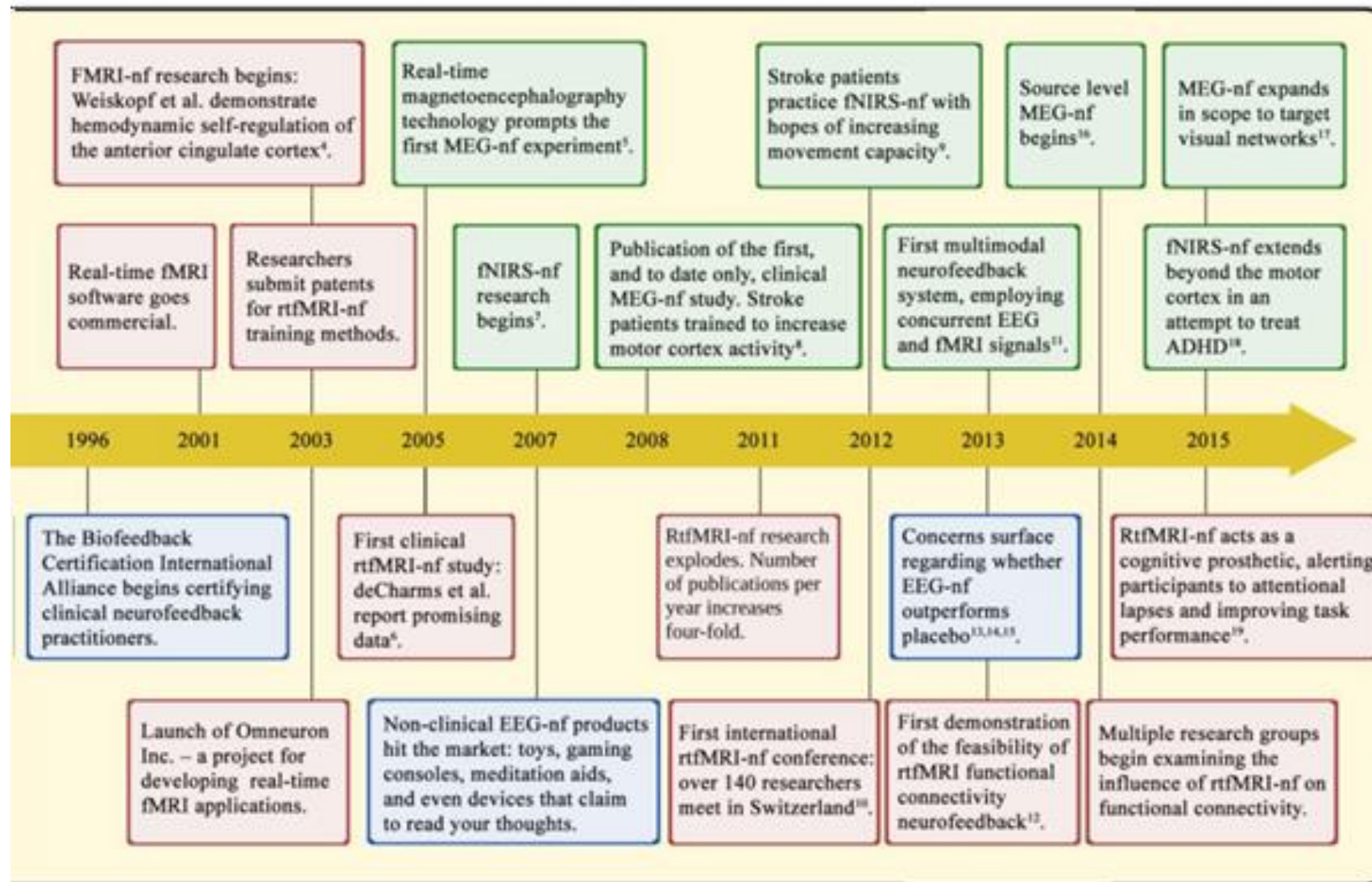


Nearly six decades of neurofeedback

■ EEG-nf
■ fMRI-nf
■ Emerging neurofeedback modalities



History of Neurofeedback



BRIEF HISTORY (SEIZURE)

- Wyrycha & Sterman, 1968

- Increasing SMR (12-15 Hz) in cats.
- NASA requested Hydrazine on seizure.
- 50 cats (*10 cats*) were injected with Hydrazine.
- The 10 trained cats were seizure resistant!

- Sterman & Friar, 1972

- Sterman, Macdonald, & Stone, 1974

- Seiferd & Lubar, 1975

- Lubar & Bahler, 1976

CERTIFICATE OF COMPLETION

Awarded to:

Mohammad Ali Nazari

In recognition of completing the workshop

**“QEEG evaluation and neurofeedback strategies and outcomes
in the treatment of epilepsy and traumatic brain injury (Part 2)”**

by

M. Barry Stermann

At the 9th Annual Meeting of the Biofeedback Foundation of Europe
Provinciale Hogeschool Limburg, Hasselt, Belgium, February 26, 2005

M. B. Stermann

Workshop instructor

Erik Peper

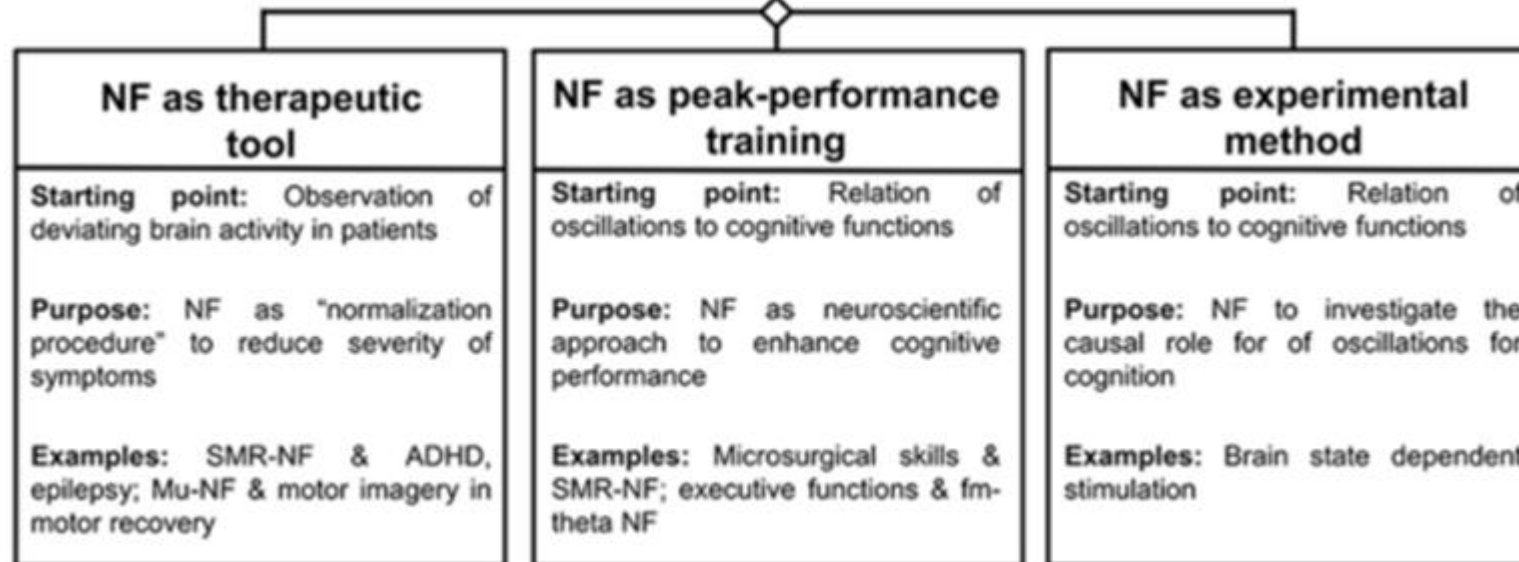
***Erik Peper, Ph.D.
President BFE***





EEG-Neurofeedback as a Tool to Modulate Cognition and Behavior: A Review Tutorial

Stefanie Enriquez-Geppert^{1*}, René J. Huster² and Christoph S. Herrmann³



EEG oscillations are causal for cognitive processes : neurofeedback

Frequency bands	Improved behavior	Frequency bands	Improved behavior
SMR	Memory in adults and children (Vernon 2003)	Frontal theta increase	Execute attention in memory recognition and special orientation improved (vang 2013)
Theta/beta decrease & SMR	Visuospatial rotation (veber 2011)	Parietal theta	Procedural learning after sleep (reiner 2013)
Theta/beta decrease & SMR	Reaction Time (veber 2011)	SMR	Declrative memory with nonRem Spindle frequency music performance (berner 2006)
SMR	Calm and reduce anxiety	Posterior alpha	Improved working (naun 2012)
SMR	Sleep spindle increase that related to improve memory (Berner 2006)	Alpha suppression	Implicit memory procedural learning (Ros 2014)
Beta1	P300 amplitude and arousal increase (egner 2004)	Beta decrease	Verbal intelligence in aged people (bekra 2012)



Neurofeedback Modulate frequencies Coupling

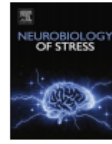
Neurobiology of Stress 8 (2018) 211–224



Contents lists available at ScienceDirect

Neurobiology of Stress

journal homepage: <http://www.journals.elsevier.com/neurobiology-of-stress/>



Influencing connectivity and cross-frequency coupling by real-time source localized neurofeedback of the posterior cingulate cortex reduces tinnitus related distress

Sven Vanneste^{a,*}, Kathleen Joos^b, Jan Ost^c, Dirk De Ridder^d

^a School of Behavioral and Brain Sciences, University of Texas, Dallas, USA

^b Department of Neurosurgery, University Hospital Antwerp, Belgium

^c BRAF²N & TRI, Sint Augustinus Hospital, Antwerp, Belgium

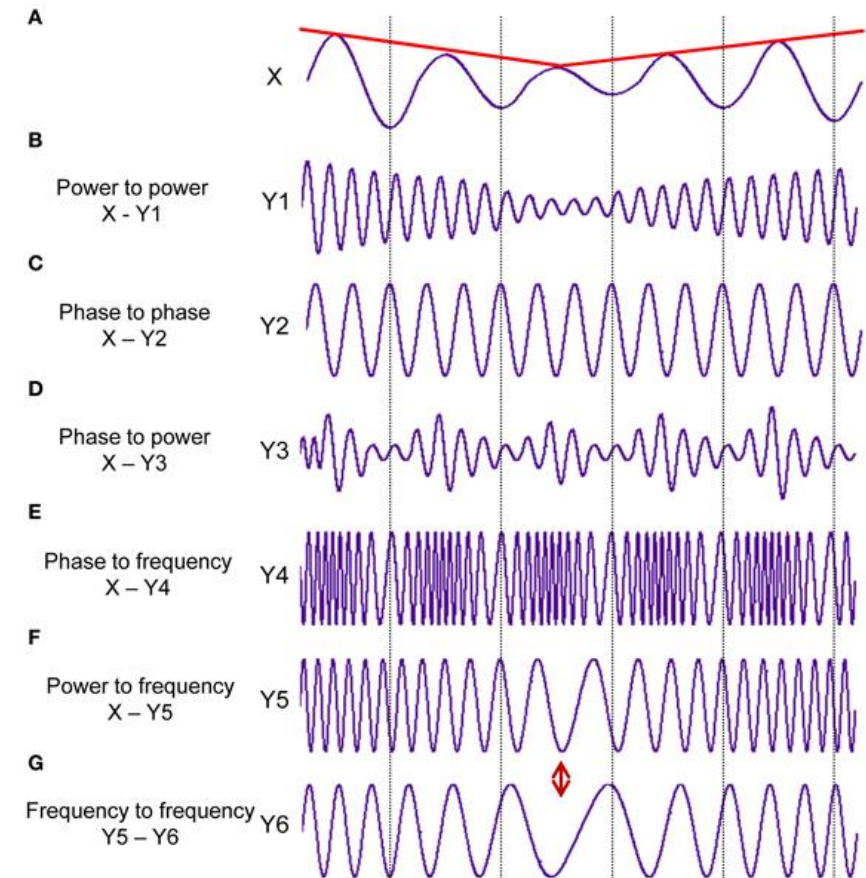
^d Section of Neurosurgery, Department of Surgical Sciences, Dunedin School of Medicine, University of Otago, New Zealand



up-training alpha and **down-training beta** and gamma activity in the **posterior cingulate cortex** has a moderating effect on tinnitus related distress

neurofeedback could remove the information, processed in beta and gamma, from the carrier wave, alpha, which transports the high frequency information and influences the salience attributed to the tinnitus sound.

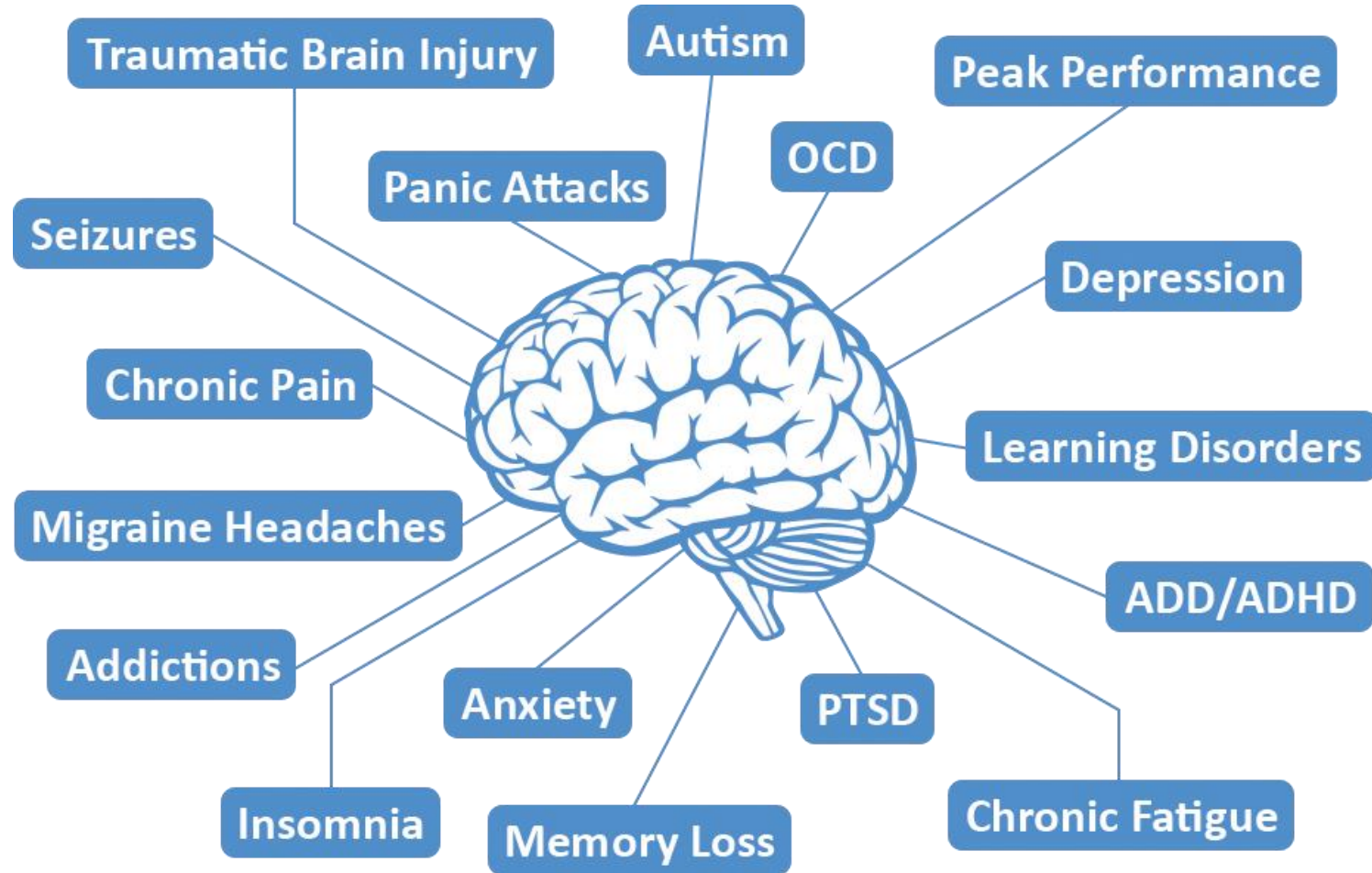
CFC has been proposed to coordinate neural dynamics across spatial and temporal scales(Aru et al., 2015).



A 1:1 mapping of brain oscillations to cognitive functions is **not possible**



Application



Neurofeedback

Introduction

History and Trends

Application

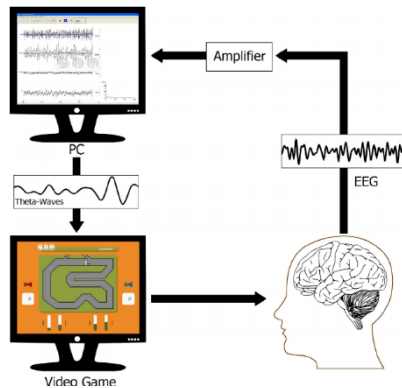
Challenges

Efficacy / inefficacy

Unknown mechanism

Practical Problem

Organizational Problem



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Publication Type

- ☐ Journal Article (3,539)
- ☐ Review (1,283)
- ☐ Conference (361)
- ☐ Study (131)
- ☐ Clinical Trial (84)
- ☐ Letters and Comments (61)
- ☐ Case Report (57)
- ☐ Editorial (54)
- ☒ Meta Analysis (35)
- ☐ News (5)

[Fewer Publication Types](#)

Publication Year

- This year (635)
- Last 5 years (3,697)
- Last 10 years (4,841)

Author

- ☐ Niels Birbaumer (97)
- ☐ D. Brandeis (38)
- ☐ Mitsuo Kawato (38)
- ☐ Ranganatha Sitaram (38)
- ☐ John H. Gruzelier (35)
- ☐ David E. J. Linden (34)
- ☐ Martijn Arns (34)
- ☐ Christa Neuper (33)
- ☐ Alireza Gharabaghi (30)
- ☐ Rainer Goebel (30)

[Fewer Authors](#)

Journals and Conferences

- ☐ NeuroImage (141)
- ☐ Front. Hum. Neurosci. (136)
- ☐ Applied psychophysiology and... (98)
- ☐ Clinical Neurophysiology (91)
- ☐ PloS one (79)
- ☐ Front. Neurosci. (47)
- ☐ IEEE Transactions on Neural... (45)
- ☐ Front. Psychol. (44)
- ☐ Clinical EEG and neuroscience (40)
- ☐ Front. Behav. Neurosci. (33)

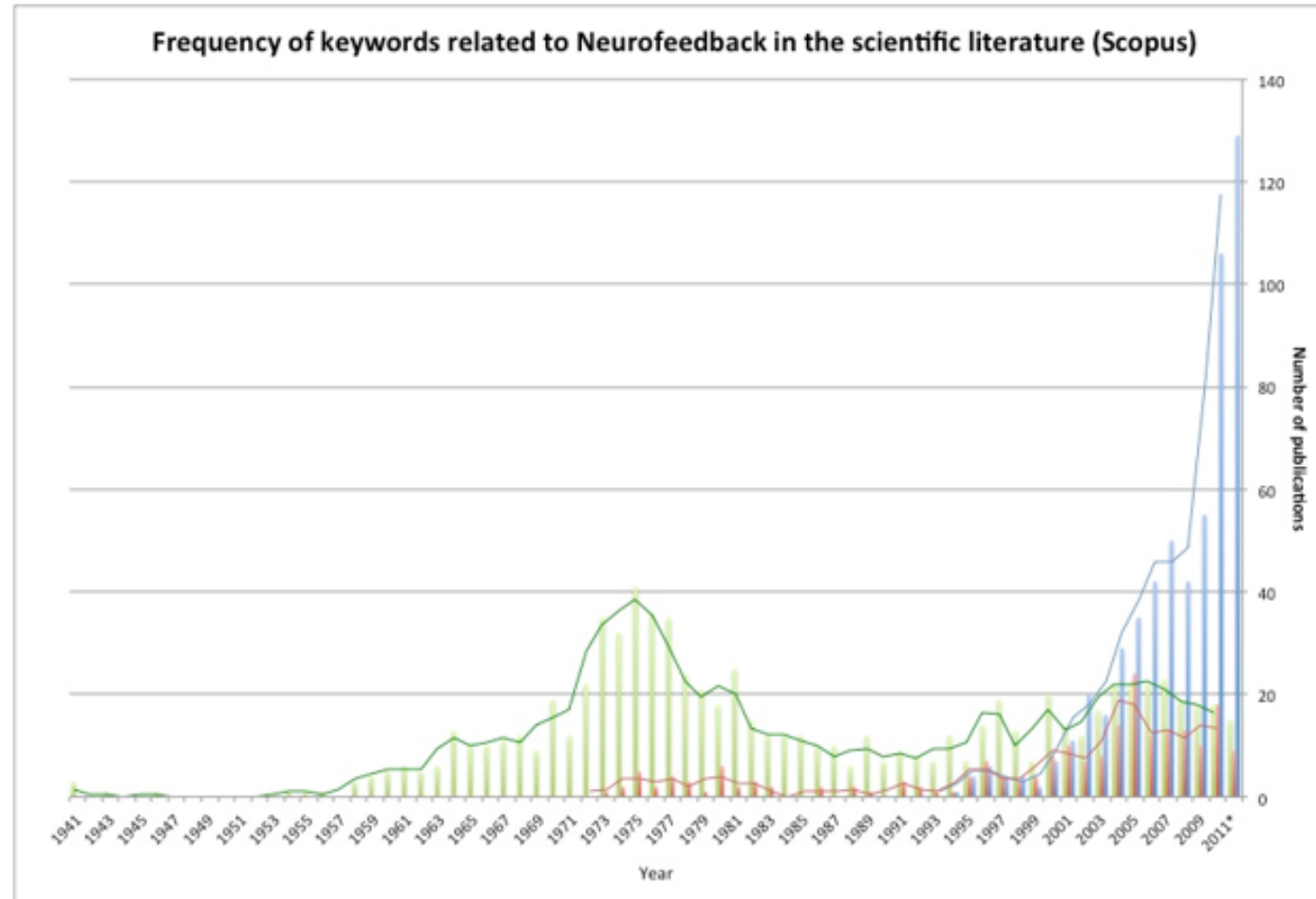
[Fewer Venues](#)

Neurofeedback treatment for attention-deficit/hyperactivity disorder in children: a comparison with methylphenidate.

📊 Results by year

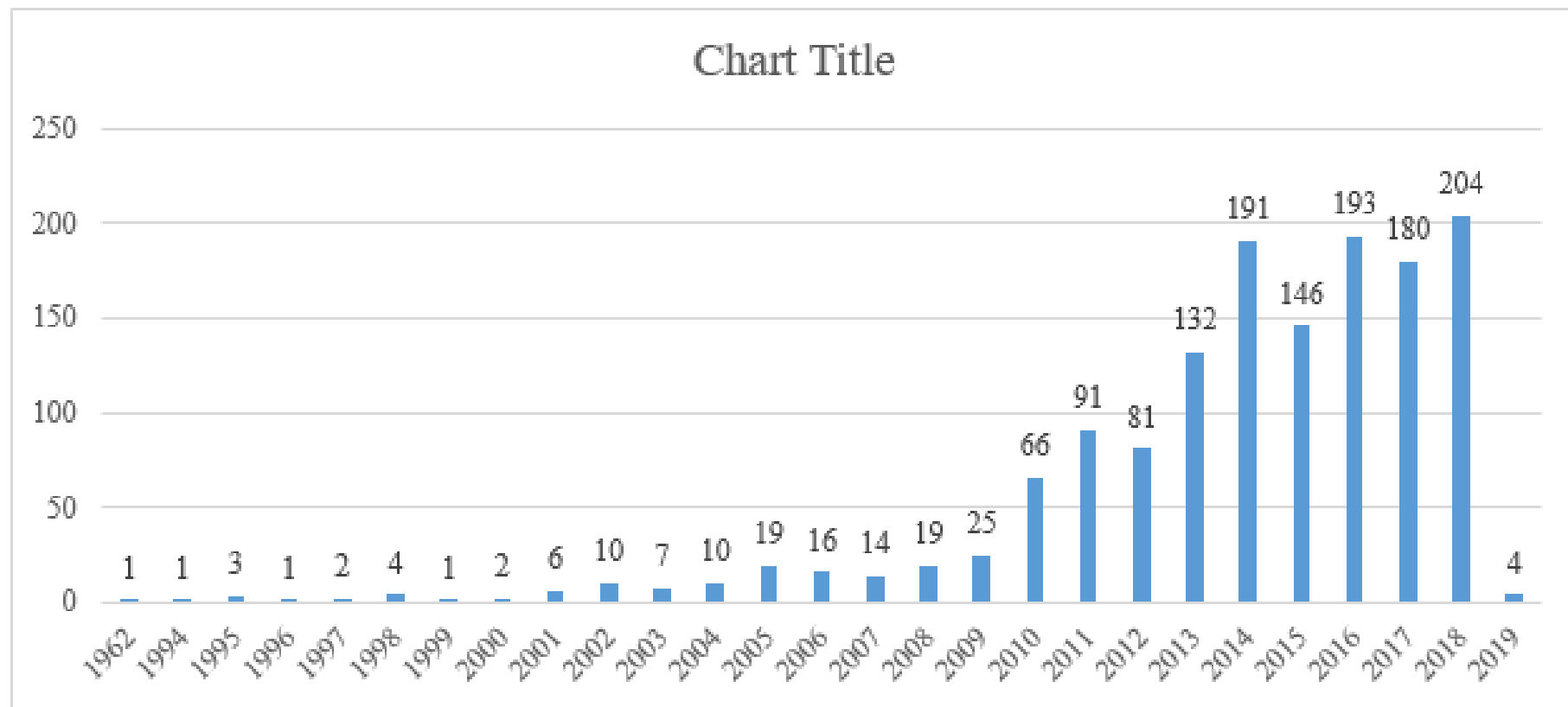
📊 Results by year





Frequency of different keywords related to neurofeedback and their frequency of occurrence in the scientific literature per year. Green reflects 'EEG AND conditioning', Red reflects 'EEG Biofeedback' and Blue reflects 'Neurofeedback'. Note that 2011* indicates the extrapolated number for 2011, based on the absolute numbers from August 15th 2011 (obtained using SCOPUS).

NFB Pubmed



Assessment criteria

General guidelines for the evaluation of the efficacy of (clinical) interventions

Level 1: Not empirically supported

- Study is published **without peer-review procedure** or is based on **anecdotal reports**.

Level 2: Possibly efficacious

- At least one study is published with **sufficient statistical power** and **well-identified outcome measures**, but **lacks random assignment** to a control condition.

Level 3: Probably efficacious

- Beneficial effects are shown in **multiple observational-, clinical-, waiting list controlled studies**, replicated with within- and between subject studies.

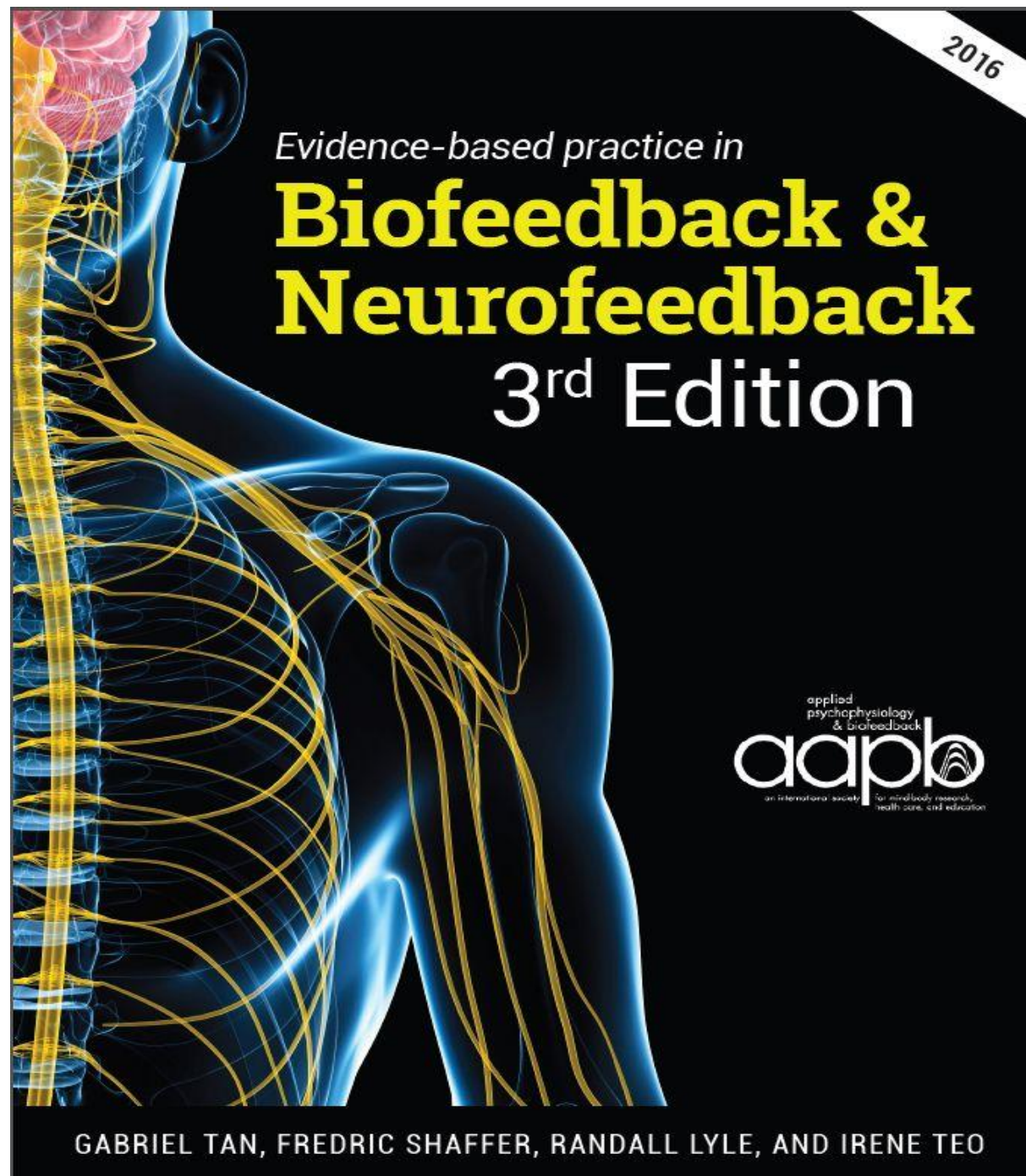
Level 4: Efficacious

- The intervention is **compared to a control group**, alternative treatment group, or a sham control using **randomized assignment**; the intervention **shows statistically superior outcome** or similar outcome compared to an established efficient intervention.
- Participants have been selected based on inclusion criteria in a reliable, operationally defined manner.
- Outcome measures are clearly specified and related to the problem that is treated.
- Data are analyzed appropriately.
- Diagnostic, treatment and the procedure are clearly defined and permits independent replication.
- The superiority or equivalence of the treatment has been shown in at least **two independent studies**.

Level 5: Efficacious and specific

- Intervention is statistically superior to a **credible** sham control, pill or bona fide treatment in at least **two independent studies** by independent researchers.

FIGURE 8 | Assessment criteria. Based on general guidelines, five levels and their criteria are listed for the evaluation of the efficacy of (clinical) interventions.



GABRIEL TAN, FREDRIC SHAFFER, RANDALL LYLE, AND IRENE TEO

Problem area	Level 5: Efficacious and specific	Level 4: Efficacious:	Level 3: Probably Efficacious:
ADHD	✓		
Depressive disorder		✓	
Anxiety& Anxiety disorder		✓	
Epilepsy		✓	
Adult Headache		✓	
Alcohol/Substance use disorder			✓
Autism			✓
Chemobrain			✓
Chronic pain			✓
Insomnia			✓
Performance Enhancement			✓
PTSD			✓
			41



Semantic Scholar

All Fields



neurofeedback

Neurofeedback

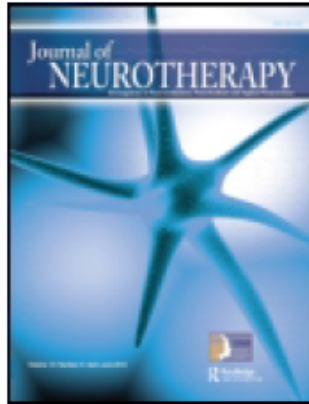
Known as: EEG biofeedback, Neurofeedbacks, biofeedback eeg

A treatment being studied to improve brain function in certain brain disorders and in patients treated with chemotherapy for breast cancer. Sensors are placed on a person's head, which allows brain activity to be shown as patterns on a computer screen. A beep or a tone may be used as a reward to a person for changing certain brain activities. Neurofeedback may help cancer patients deal with the stress and mental side effects of chemotherapy. [\(Less\)](#)



National Institutes of Health

Why inefficacy



Journal of Neurotherapy

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/vneu20>

Neurofeedback and Basic Learning Theory: Implications for Research and Practice

Leslie H. Sherlin^{a b c}, Martijn Arns^{d e}, Joel Lubar^f, Hartmut Heinrich^{g h}, Cynthia Kerson^{i j k}, Ute Strehl^l & M. Barry Sterman^m

^a Neurotopia, Inc., Los Angeles, California, USA

^b Nova Tech EEG, Inc., Mesa, Arizona, USA

^c Southwest College of Naturopathic Medicine, Tempe, Arizona, USA

^d Research Institute Brainclinics, Nijmegen, The Netherlands

^e Department of Experimental Psychology, Utrecht University, Utrecht, The Netherlands

^f University of Tennessee, Knoxville, Tennessee, USA

^g Department of Child and Adolescent Mental Health, University of Erlangen-Nürnberg, Erlangen, Germany

^h Heckscher-Klinikum, München, Germany

ⁱ ISNR Research Foundation, San Rafael, California, USA

^j Brain Science International, Pleasanton, California, USA

^k Marin Biofeedback, San Rafael, California, USA

^l University of Tübingen, Tübingen, Germany

^m University of California, Los Angeles, California, USA

Available online: 30 Nov 2011

Why inefficacy

NEUROSCIENCE

REVIEW

O. Alkoby et al. / Neuroscience 378 (2018) 155–164



Can We Predict Who Will Respond to Neurofeedback? A Review of the Inefficacy Problem and Existing Predictors for Successful EEG Neurofeedback Learning

O. Alkoby,^a A. Abu-Rmileh,^a O. Shriki^{a*} and D. Todder^{b,c}

^a *Department of Cognitive and Brain Sciences, Ben-Gurion University of the Negev, Beer-Sheva, Israel*

^b *Faculty of Health, Ben-Gurion University of the Negev, Beer-Sheva, Israel*

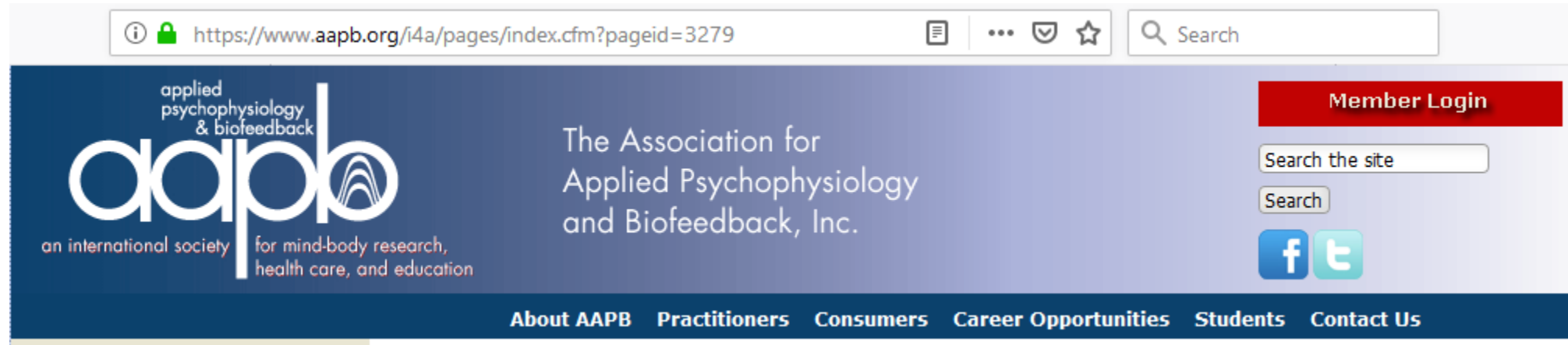
^c *Beer-Sheva Mental Health Center, Israel Ministry of Health, Beer-Sheva, Israel*

Abstract—Despite the success of neurofeedback treatment in many cases, the variability in the efficacy of the treatment is high, and some studies report that a significant proportion of subjects does not benefit from it. Quantifying the extent of this problem is difficult, as many studies do not report the variability among subjects

Activate Windows
Go to Settings to activate

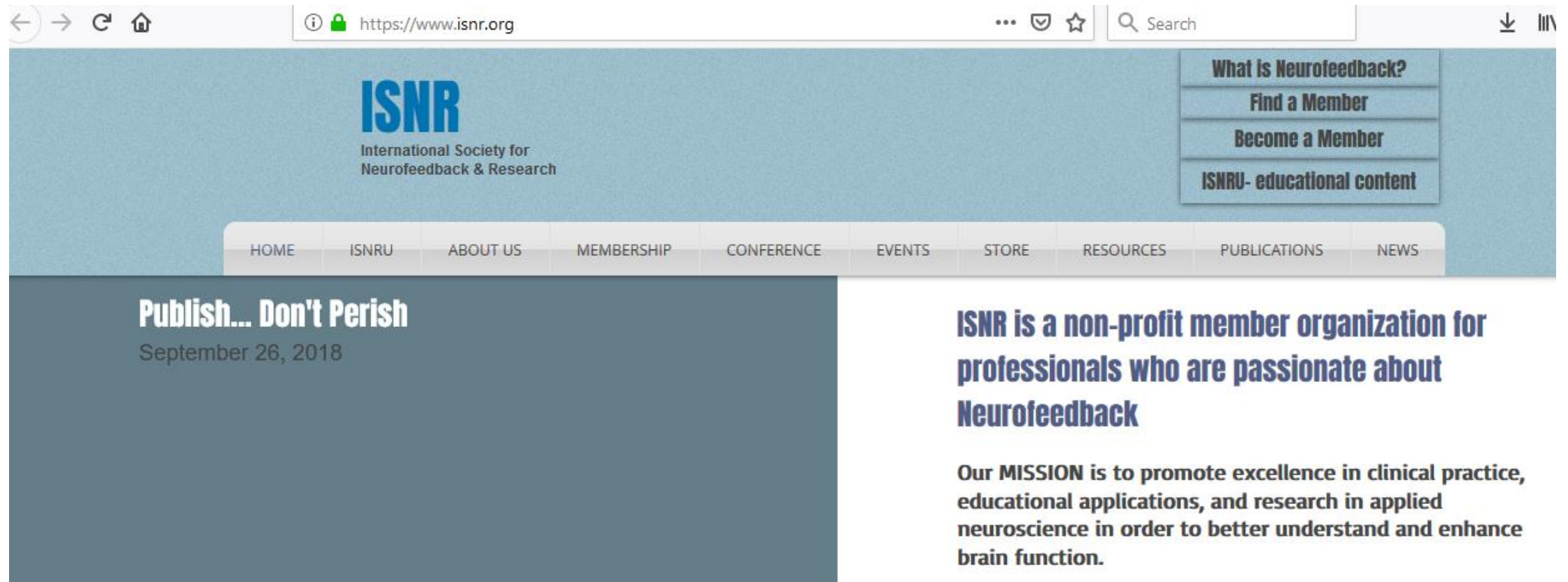
Why inefficacy

- Organizational Issue



Why inefficacy

- Organizational Issue



The screenshot shows the homepage of the International Society for Neurofeedback & Research (ISNR). The browser address bar displays "https://www.isnr.org". The website header features the ISNR logo and a navigation menu with links: HOME, ISNRU, ABOUT US, MEMBERSHIP, CONFERENCE, EVENTS, STORE, RESOURCES, PUBLICATIONS, and NEWS. On the right side of the header, there are four stacked buttons: "What is Neurofeedback?", "Find a Member", "Become a Member", and "ISNRU- educational content". The main content area is divided into two columns. The left column has a dark blue background with the text "Publish... Don't Perish" and the date "September 26, 2018". The right column has a white background with the text "ISNR is a non-profit member organization for professionals who are passionate about Neurofeedback" and a paragraph about the organization's mission.

ISNR
International Society for
Neurofeedback & Research

What is Neurofeedback?
Find a Member
Become a Member
ISNRU- educational content

HOME ISNRU ABOUT US MEMBERSHIP CONFERENCE EVENTS STORE RESOURCES PUBLICATIONS NEWS

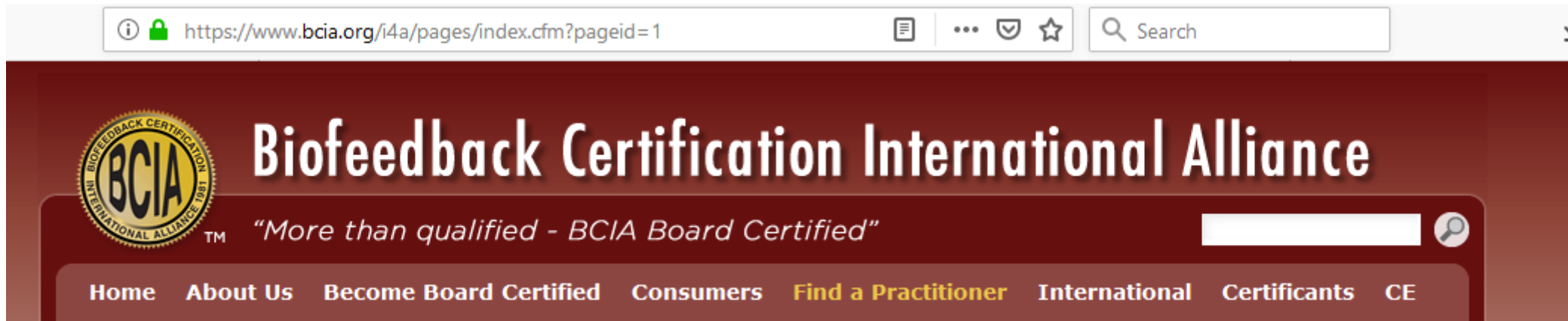
Publish... Don't Perish
September 26, 2018

ISNR is a non-profit member organization for professionals who are passionate about Neurofeedback

Our **MISSION** is to promote excellence in clinical practice, educational applications, and research in applied neuroscience in order to better understand and enhance brain function.

Why inefficacy

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There were 41 results matching your search criteria.

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Click on the column header to sort the results

1 2

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T: Application Type; Act: Activity Code; Project: Admin IC, Serial No.; Year: Support Year/Supplement/Amendment

<input type="checkbox"/>	T	Act	Project	Year	Sub #	Project Title	Contact PI/ Project Leader	Organization	FY	Admin IC	Funding IC	FY Total Cost by IC	Similar Projects
<input type="checkbox"/>	3	R01	MH100144	05S1		DOUBLE-BLIND RANDOMIZED CLINICAL TRIAL OF EEG NEUROFEEDBACK FOR ADHD	ARNOLD, L EUGENE	OHIO STATE UNIVERSITY	2018	NIMH	NIMH	\$99,005	v
<input type="checkbox"/>	5	R01	MH100144	05		DOUBLE-BLIND RANDOMIZED CLINICAL TRIAL OF EEG NEUROFEEDBACK FOR ADHD	ARNOLD, L EUGENE	OHIO STATE UNIVERSITY	2018	NIMH	NIMH	\$755,391	v
<input type="checkbox"/>	1	ZIC	MH002884	11		FUNCTIONAL MRI CORE FACILITY	BANDETTINI, PETER	NATIONAL INSTITUTE OF MENTAL HEALTH	2017	NIMH	NIMH	\$4,053,263	v
<input type="checkbox"/>	5	R01	HD086888	04		CRCNS: US-FRANCE MODELING & PREDICTING BCI LEARNING FROM DYNAMIC NETWORKS	BASSETT, DANIELLE SMITH	UNIVERSITY OF PENNSYLVANIA	2018	NICHD	NICHD	\$123,717	v
<input type="checkbox"/>	5	R01	HD071686	07		SHAPING NEURAL POPULATION DYNAMICS TO FACILITATE LEARNING	BATISTA, AARON PAUL et al.	UNIVERSITY OF PITTSBURGH AT PITTSBURGH	2018	NICHD	NICHD	\$441,867	v
<input type="checkbox"/>	5	R01	AA021529	05		THE REPAIR OF SELF CONTROL IN ALCOHOL DEPENDENCE: WORKING MEMORY & REAL TIME FMRI	BICKEL, WARREN K et al.	VIRGINIA POLYTECHNIC INST AND ST UNIV	2017	NIAAA	NIAAA	\$548,292	v

Activate
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Thank you for your attention

nazaripsycho@yahoo.com

Nazari_neuro

Neurofeedback_clinic