# *Functional Near Infrared Spectroscopy*


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journal homepage

NeuroImage

Review

# A brief review on the history of hum… spectroscopy (fNIRS) development …

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*Department of Health Sciences, University of L'Aquila, L'Aquila, Italy*

REPORTS

# Noninvasive, infrared monitoring of cerebral and myocardial oxygen sufficiency and circulatory parameters

FF Jobsis

*Science* 23 Dec 1977:
Vol. 198, Issue 4323, pp. 1264-1267
DOI: 10.1126/science.929199

***Un pò di storia***

1800 by Sir Frederick William Herschel

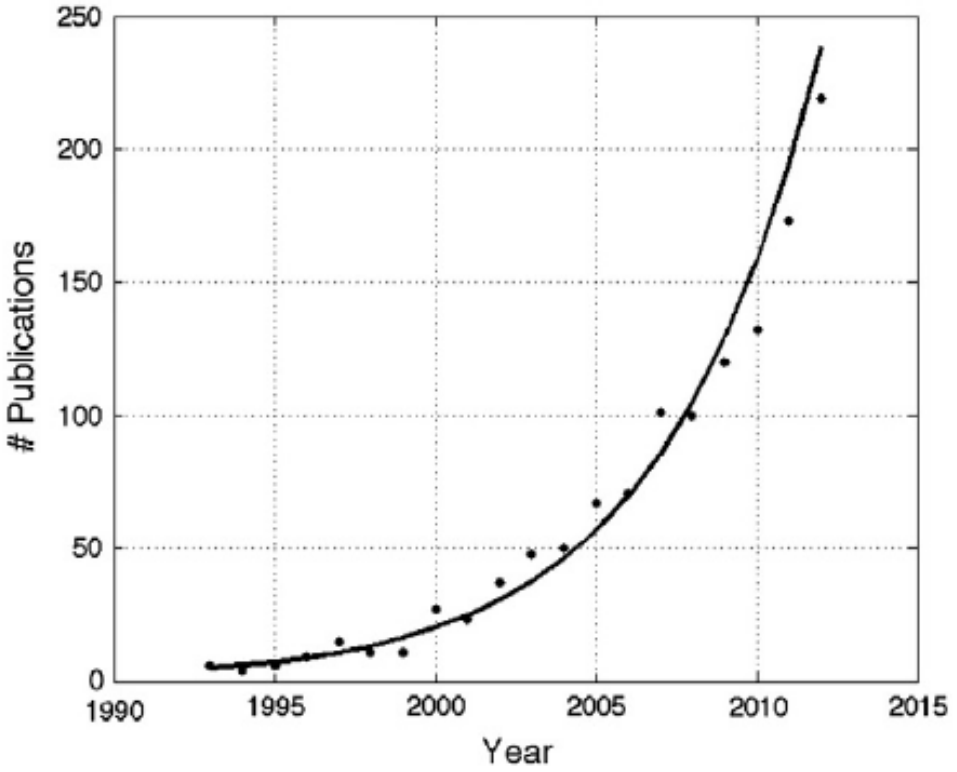


**Fig. 1.** Number of fNIRS publications per year.

# *Outline*

***Part 1***

***Physical principles of Functional Near InfraRed Spectroscopy (fNirs)***

***Part 2***

***Application of fNIRS to clinical Neurology***

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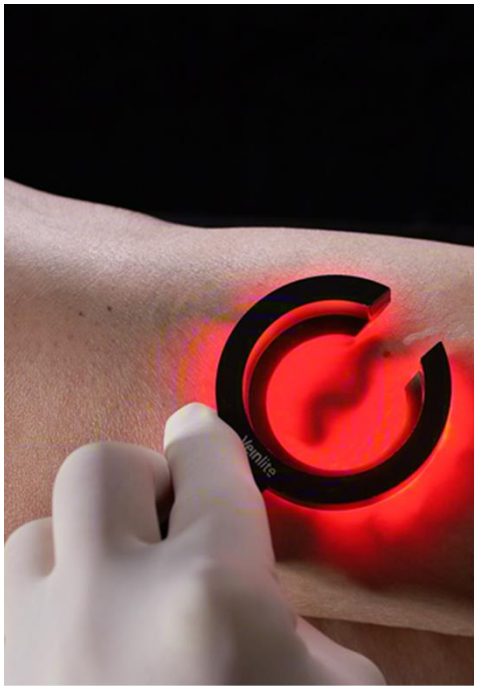
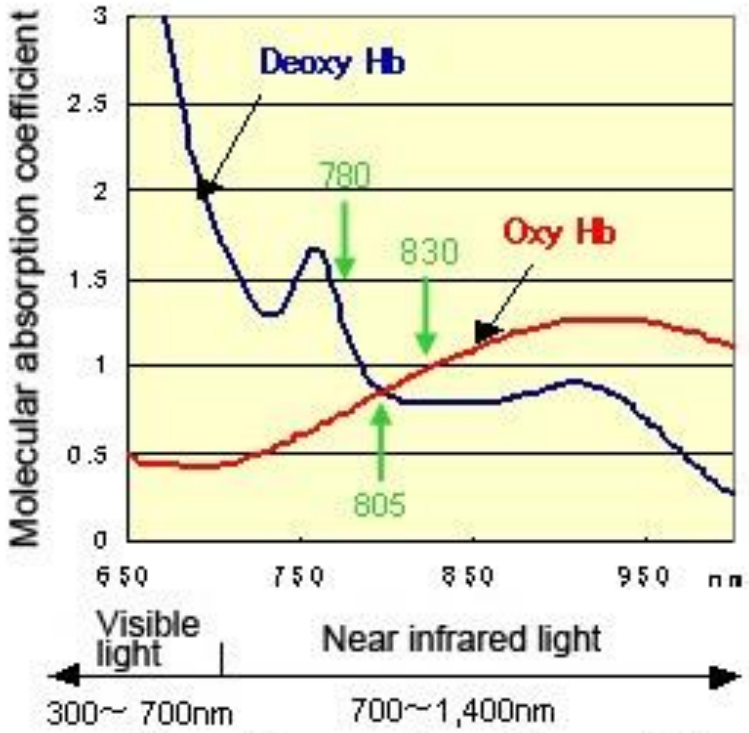
# *Why near infrared light*

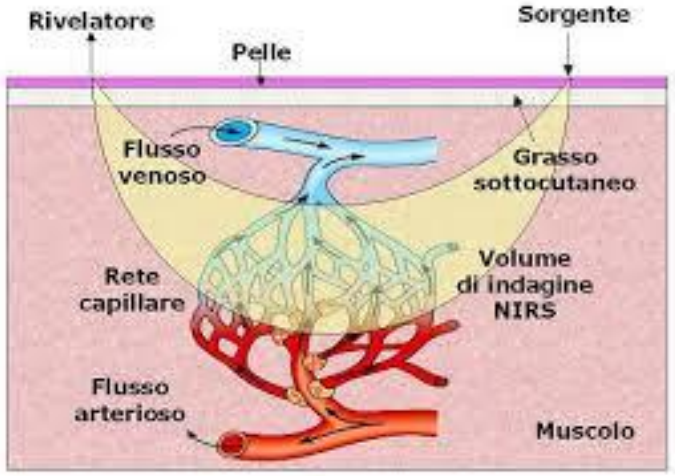
Because the near infrared light is relatively poorly absorbed by biological tissues.

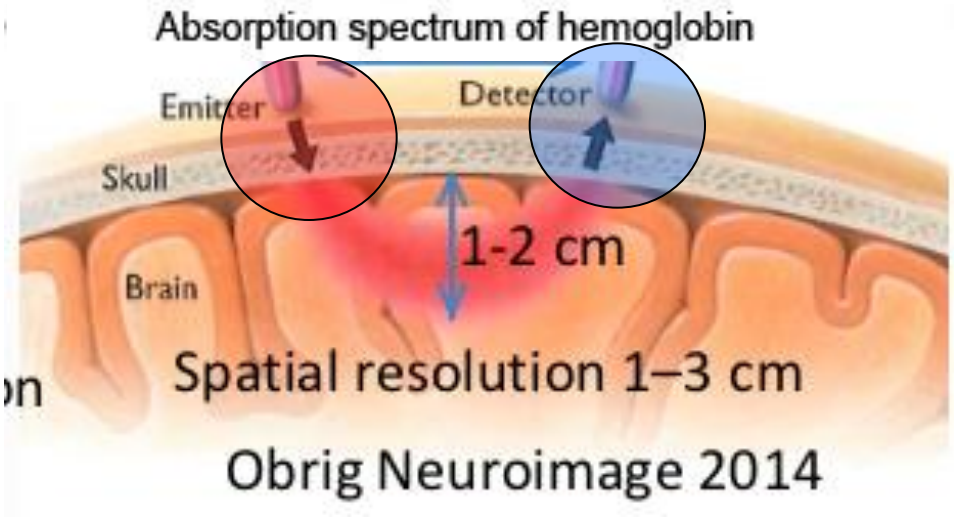


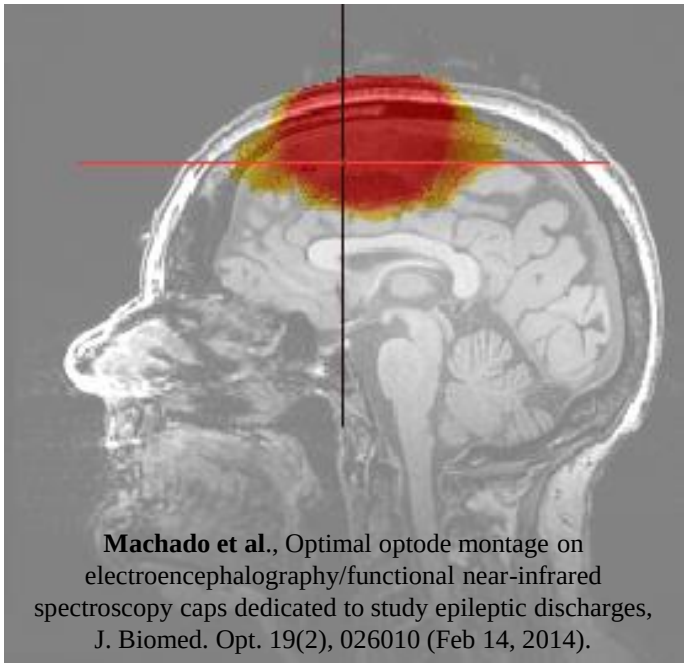
…but it is absorbed by the hemoglobin in a consistent way

# *The propagation model of light in tissues*



**Machado et al.**, Optimal optode montage on electroencephalography/functional near-infrared spectroscopy caps dedicated to study epileptic discharges, J. Biomed. Opt. 19(2), 026010 (Feb 14, 2014).

# *Hemodynamic time course plot during a motor task*

Finger tapping task

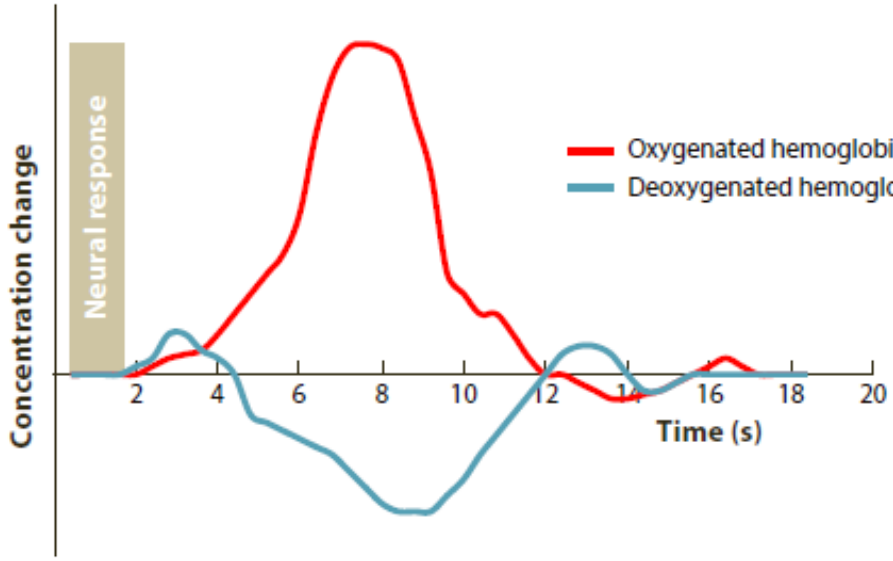
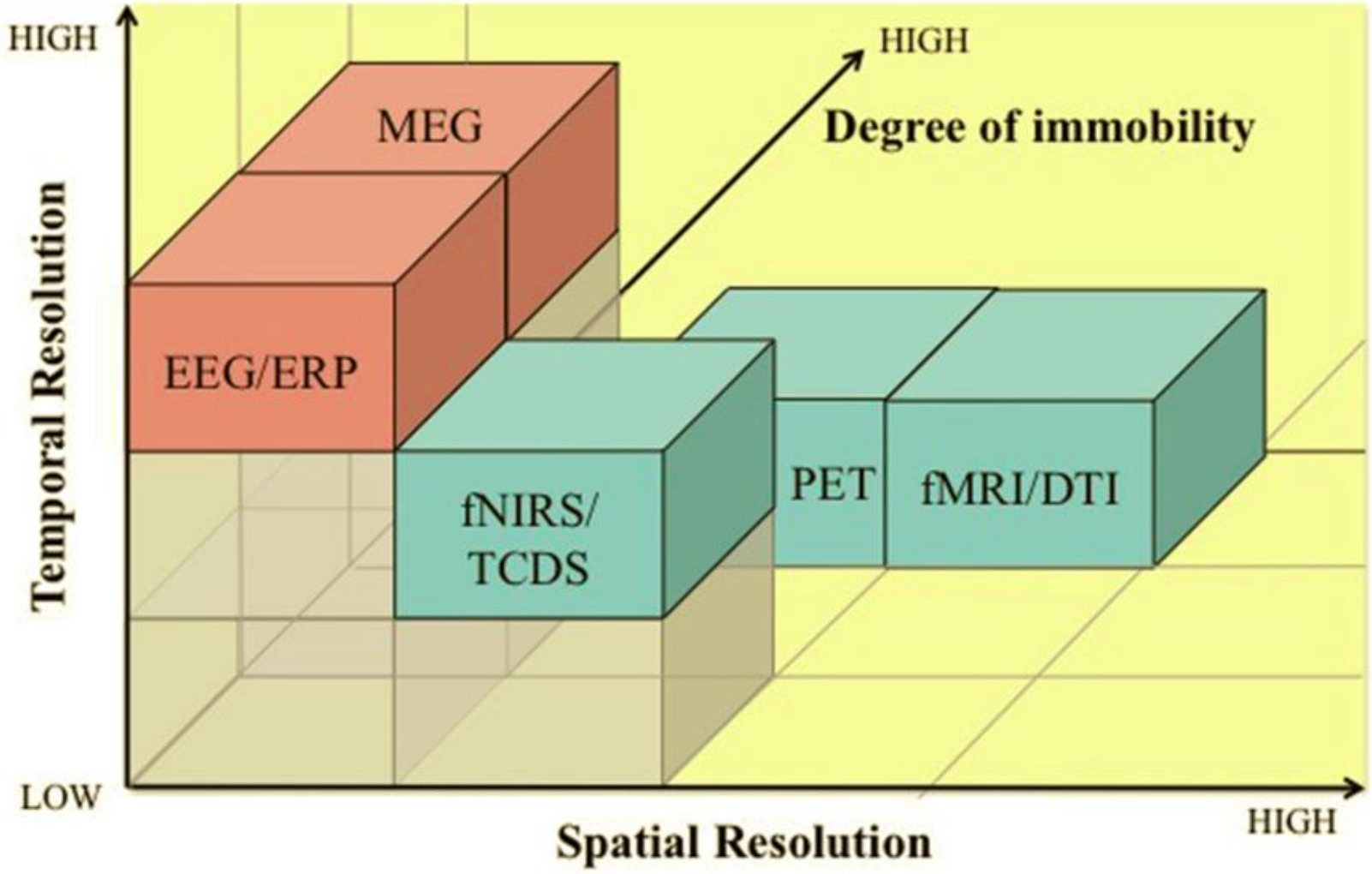



**Figure 1**

Depiction of the canonical hemodynamic response, with decreases in deoxygenated hemoglobin and increases in oxygenated hemoglobin that are delayed by several seconds after a brief stimulus and its elicited neural activity (*shaded region*). Adapted from Gervain et al. (2011) with permission.

# *fNirs and conventional imaging modalities comparison*




https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4729011/

# *fNirs instrumentation*

# *fNIRS*

- **Streghths**

**1)** long-term, noninvasive monitoring

**2)** high temporal resolution (0.1 sec)

**3)** compact, portable, and potentially wireless design

**4)** less susceptible to movement artifacts

**5)** relatively inexpensive

**6)** **natural settings** (e.g. real human interactions)

- **Weaknesses**

1) stable contact between source/detector and skin is critical

**2)** **low spatial resolution**

3) no standardization is available for NIRS signal processing analysis and statistics procedures

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***Physical principles of Functional Near InfraRed Spectroscopy (fNirs)***

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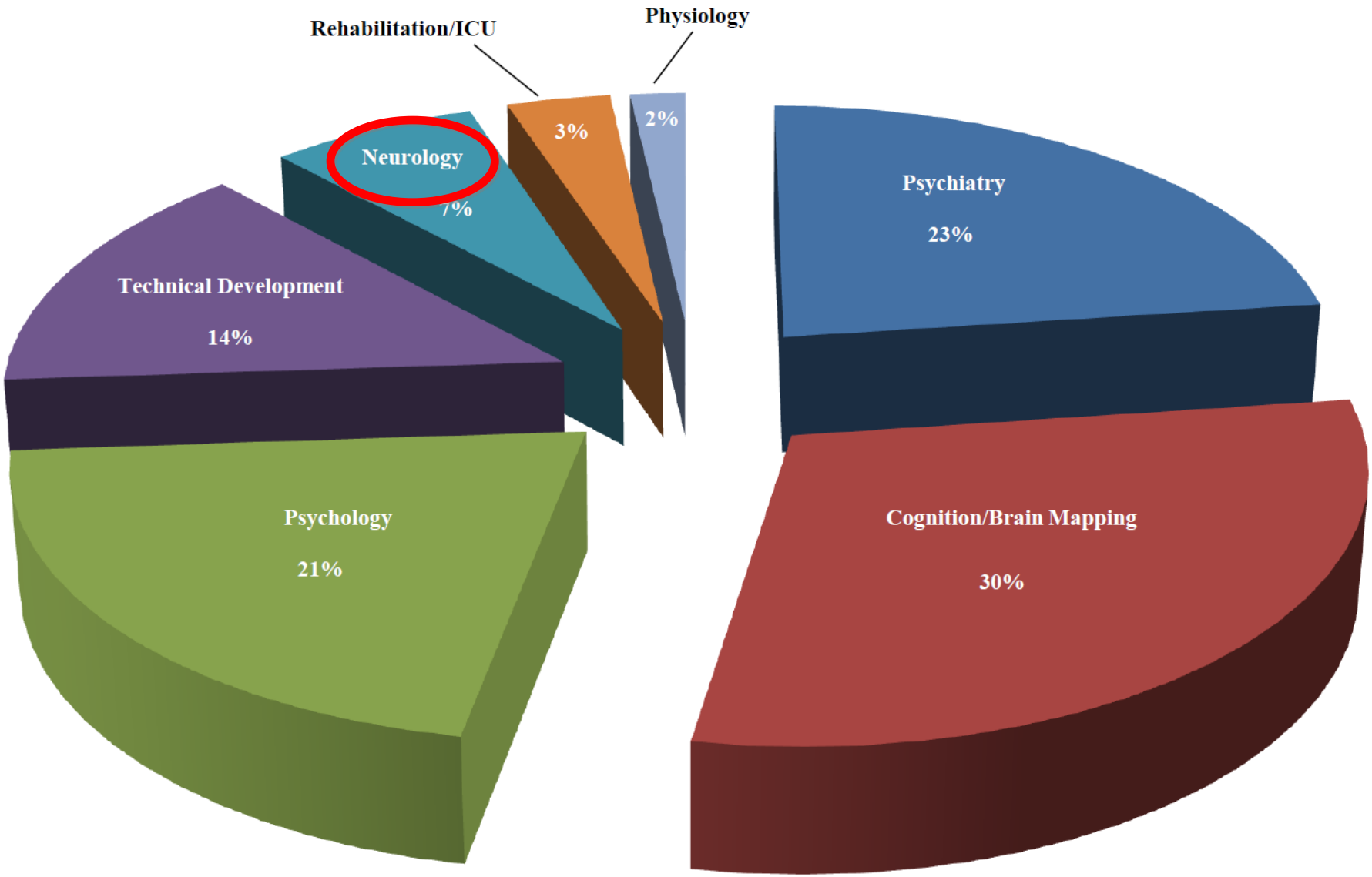
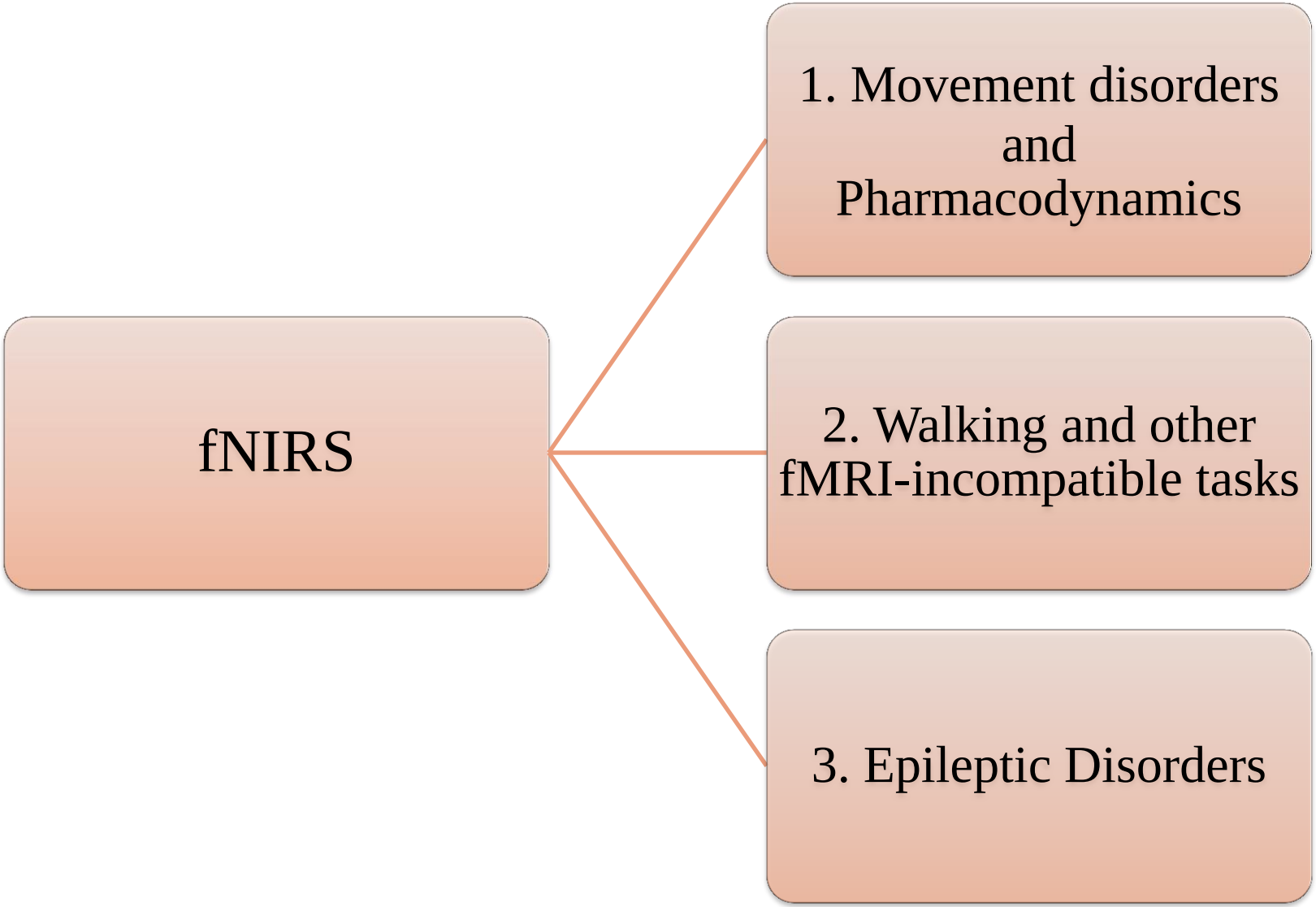
# *fNirs applications*

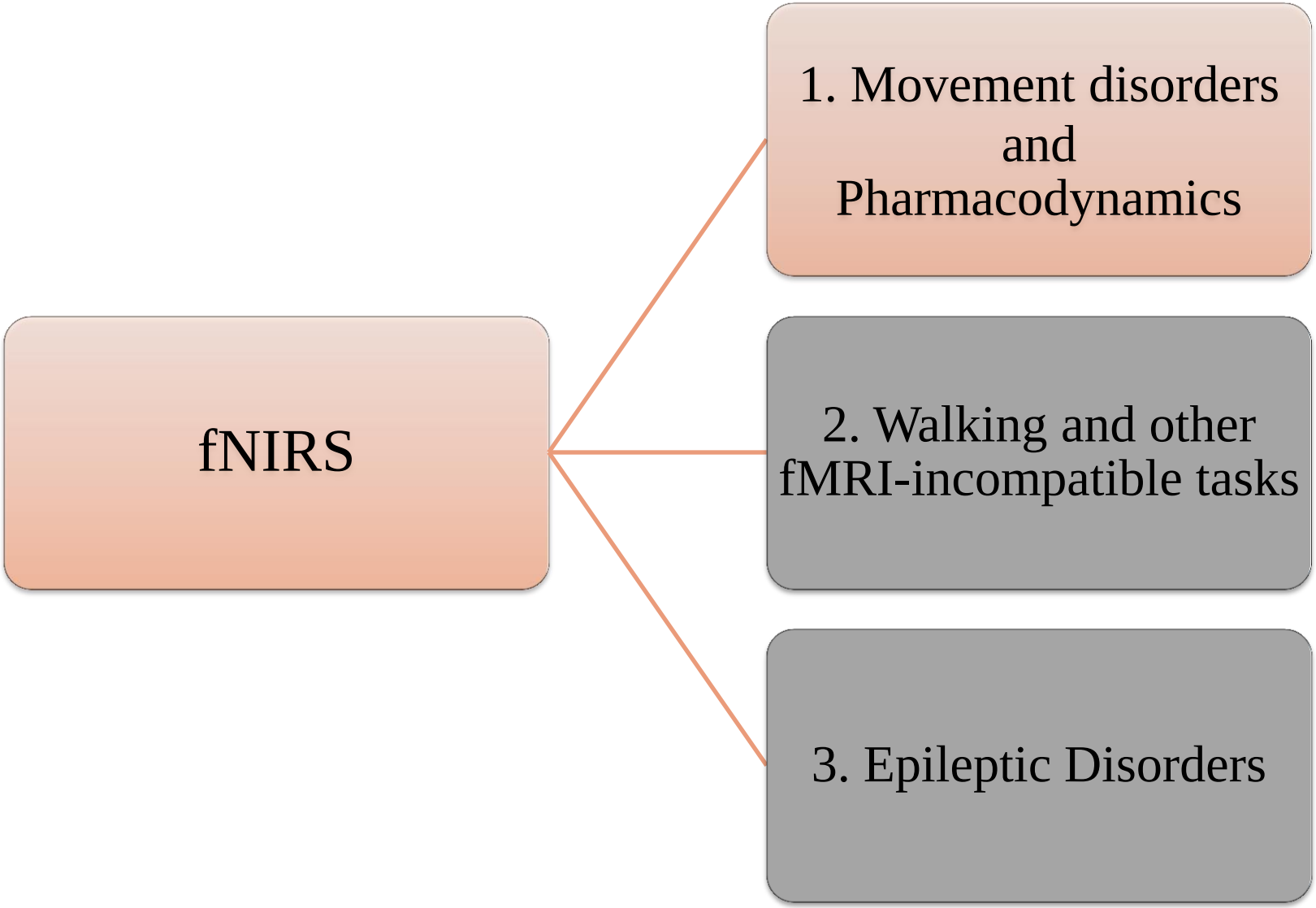



Categorized publications, 2000/2016, Hitachi.

## *When fNIRS can go beyond fMRI...*

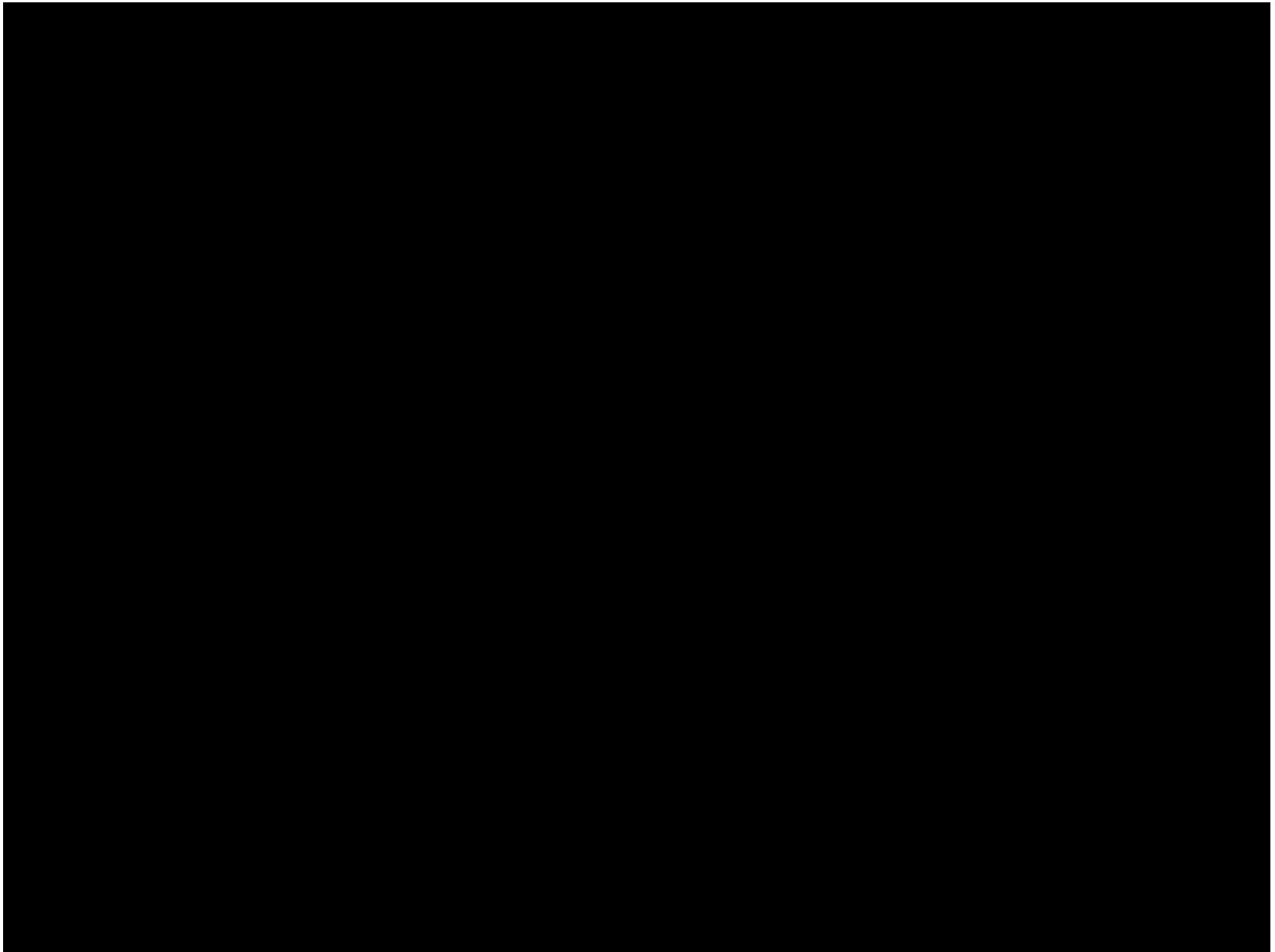


## *When fNIRS can go beyond fMRI...*



# Motor Disorders:

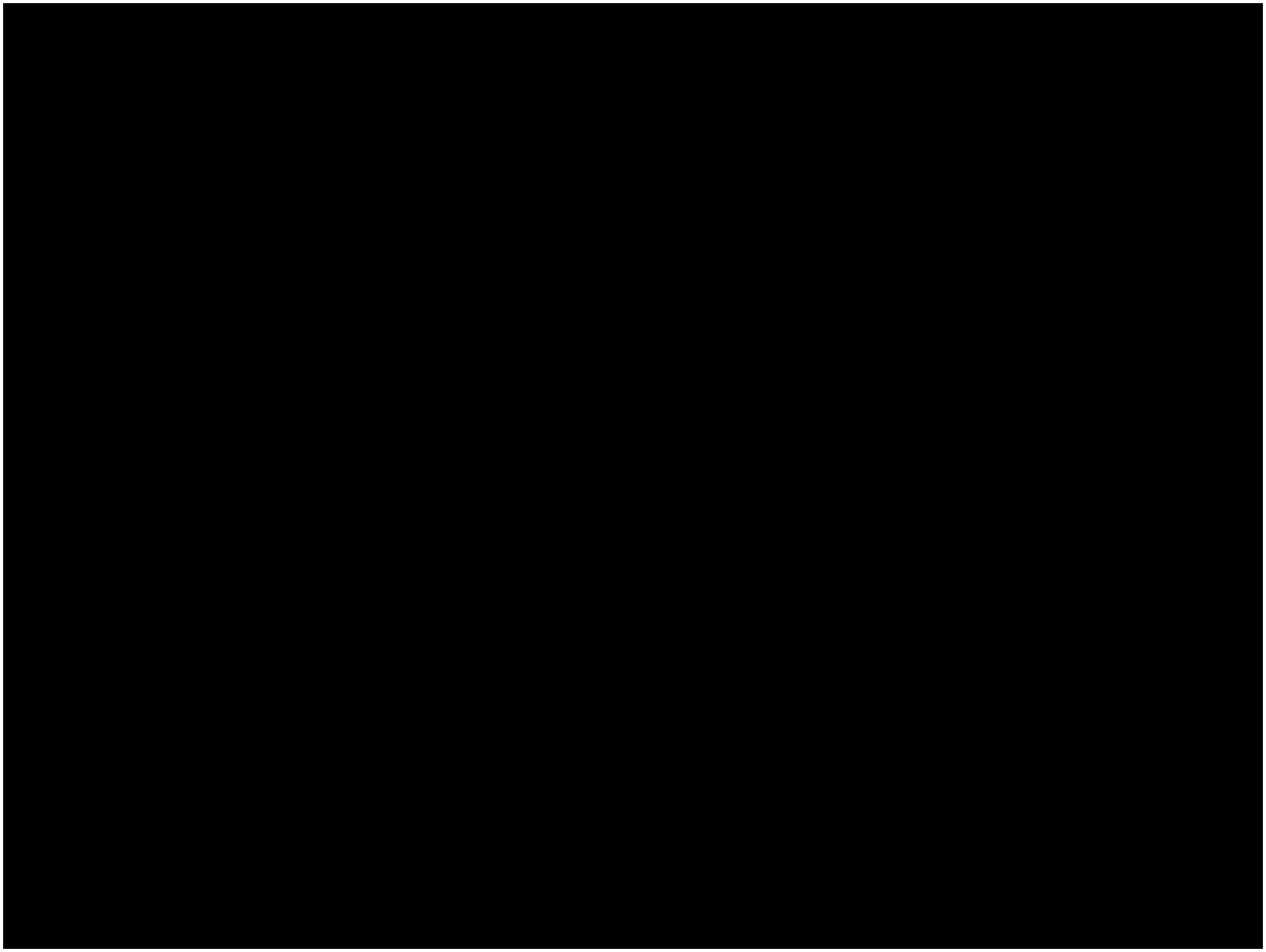
## *Parkinson's Disease & Essential Tremor*



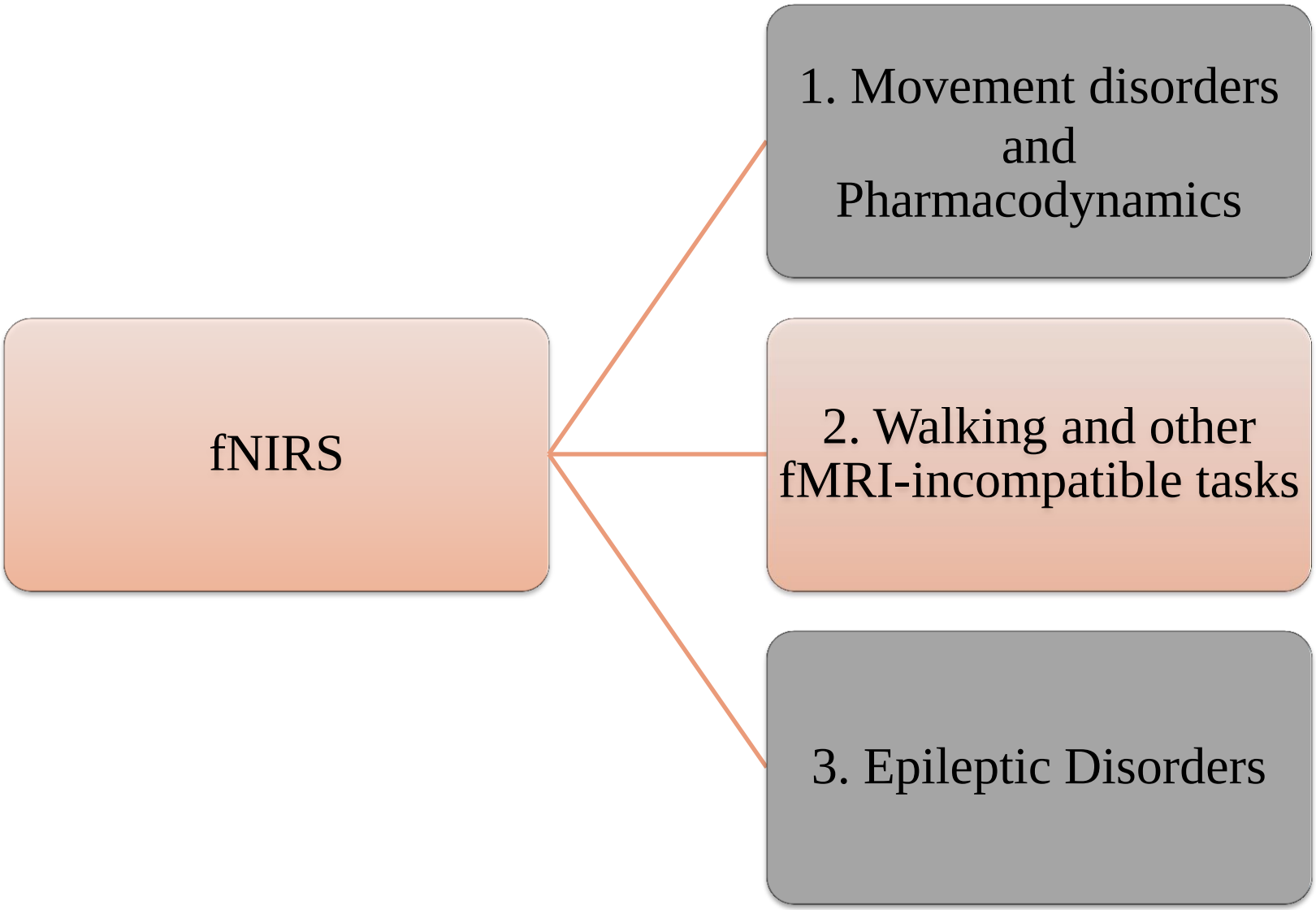
# Motor Disorders:
## *Pharmacodynamics- fMRI*

Cerasa et al., Brain, 2015: 138; 414–427.

# Motor Disorders:
## *Pharmacodynamics-fNIRS*



## *When fNIRS can go beyond fMRI...*



# Near-Infrared Spectroscopy in Gait Disorders: Is It Time to Begin?

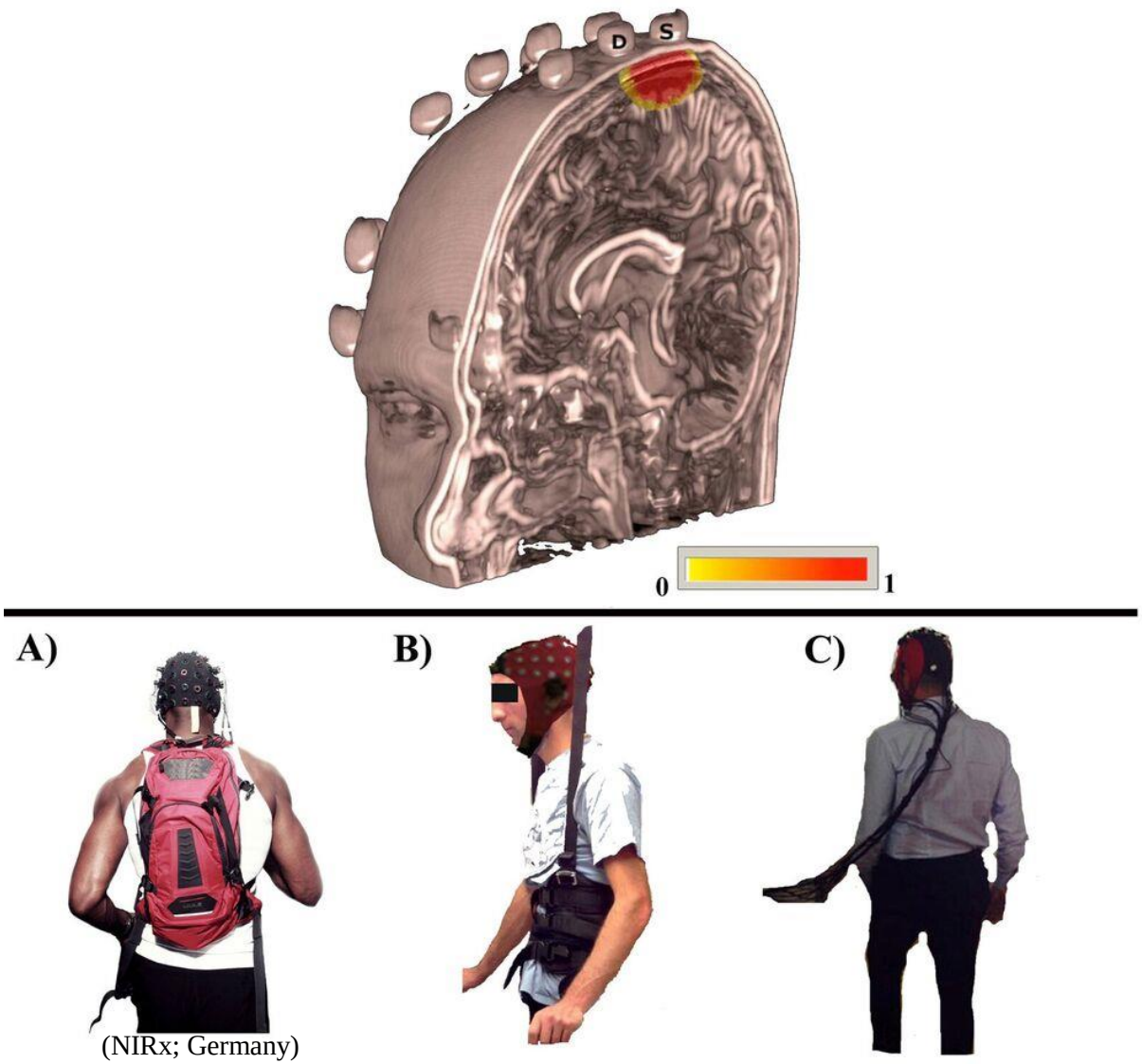
Neurorehabilitation and
Neural Repair
1–11

DOI: 10.1177/1545968317693304
journals.sagepub.com/home/nnr
SAGE

Vera Gramigna[1,†], Giovanni Pellegrino[2,†], Antonio Cerasa[1,3], Simone Cutini[4], Roberta Vasta[1], Giuseppe Olivadese[3], Iolanda Martino[1], and Aldo Quattrone[1,3]


**Mahoney** et al. 2016

Examples of **fNIRS experimental device** used for assessing brain activity during real walking tasks.




(NIRx; Germany)

## What fNIRS Teaches Us About Gait Control in Neurological Patients

**HC:**

Compensatory activities in the **prefrontal** and **premotor cortices** as a response to task complexity or aging, is observed.

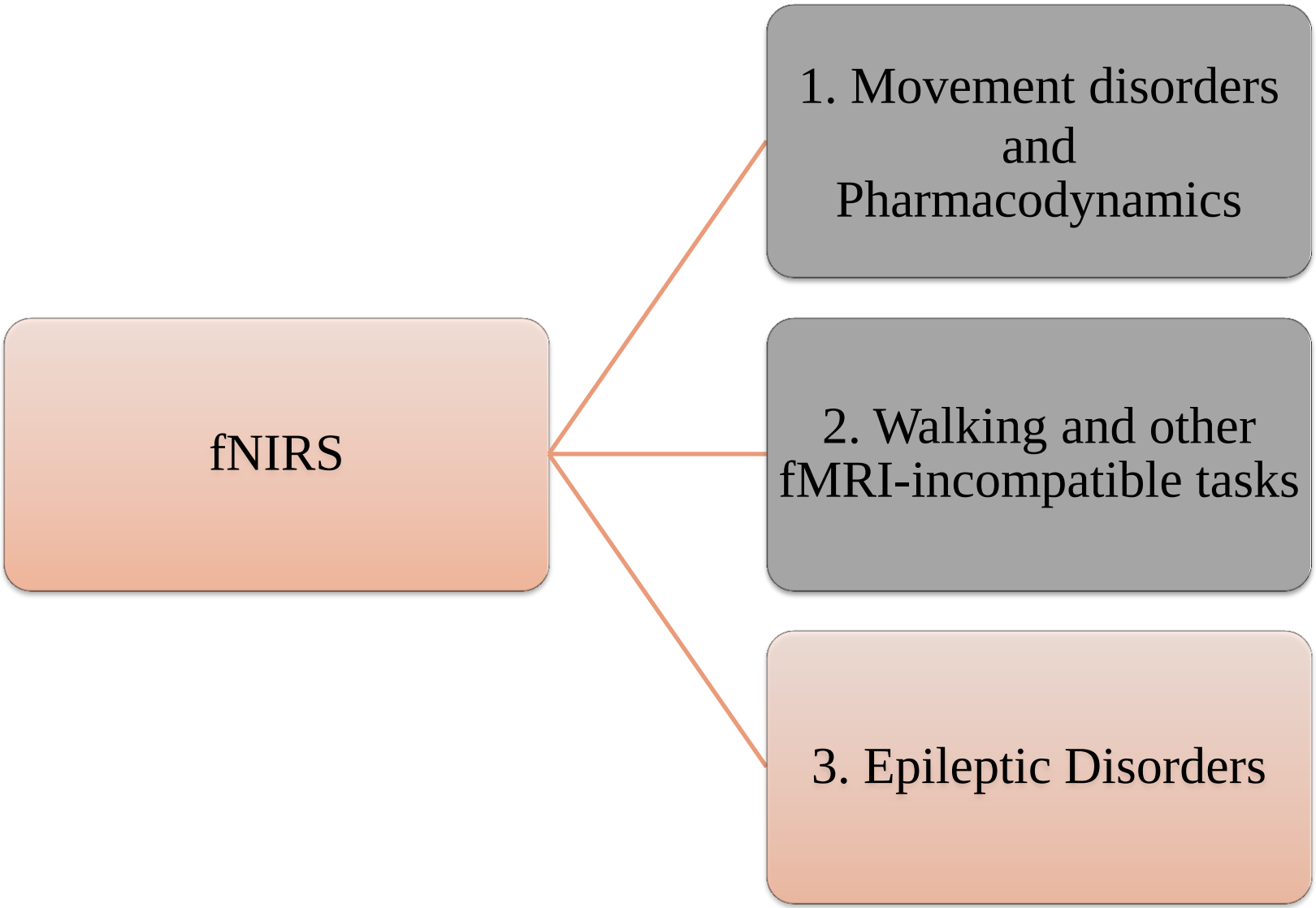
**STROKE:**

Both **PFC and bilateral frontoparietal cortices** are involved in real bipedal walking, as well as in active cycling.

**PD:**

**PFC** in involved either during postural control or during the emergency of FOG symptoms.

## *When fNIRS can go beyond fMRI...*



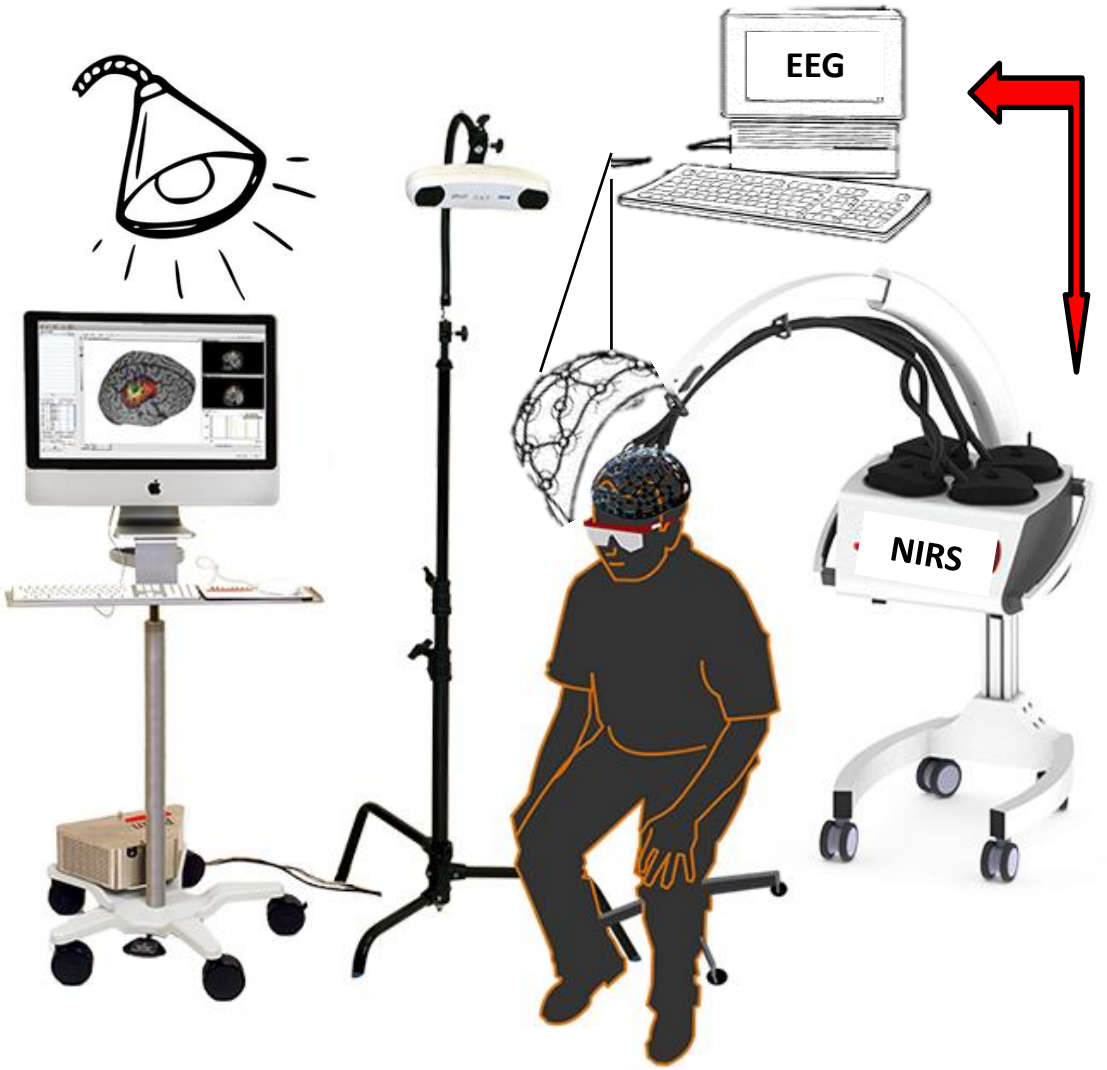
# *fNIRS in clinical neurology...*

*H. Obrig / NeuroImage 85 (2014) 535–546*

**Table 2**
Methodologies routinely used in clinical neurology. Methods are roughly differentiated with regard to their relevance for the respective diagnosis. ++: high, +: some relevance in the diagnostic algorithm. (+) indicates that procedure is warranted in subgroups of patients. MRI: magnetic resonance imaging; CT: computed tomography; PET: positron emission tomography; SPECT: single photon emission tomography; EEG: electroencephalography; EP: evoked potentials; TCD/ECD: transcranial/extracranial Doppler sonography; LP: lumbar puncture.

| | MRI | CT | PET/ SPECT | EEG | EP | TCD/ ECD | LP | Potential of NIRS | |
|---|---|---|---|---|---|---|---|---|---|
| Cerebrovascular disease | ++ | ++ | (+) | | | + | (+) | High | Monitoring: oxygenation/ perfusion/ autoreg.; prim. & secondary prevention |
| Epileptic disorders | + | | | ++ | | | (+) | High | Second. hypoxic injury; focus and preoperative function localization |
| Severe brain injury | ++ | ++ | | + | + | | | High | Monitoring: oxygenation/ perfusion/autoregulation |
| Headache | + | | | + | | | + | Med. | Neurovascular alterations |
| Dementia | + | | ++ | (+) | | | (+) | Low | Vascular dementia, cognitive function |
| Parkinson's disease | (+) | | ++ | | | | | Low | Cortical activation in response to DBS |
| Multiple sclerosis | ++ | | | | ++ | | ++ | Low | Cognitive function /fatigue |
| CNS tumors | ++ | + | (+) | (+) | | | (+) | Med. | Preoperative function localization |
| CNS infections | + | | | (+) | | | ++ | Low | Neuro-intensive care monitoring |
| Functional activation in brain disease | + | | + | + | + | (+) | | High | Assessement in 'natural' setting; plasticity in response to rehabilitation. |

# *fNirs alone?*



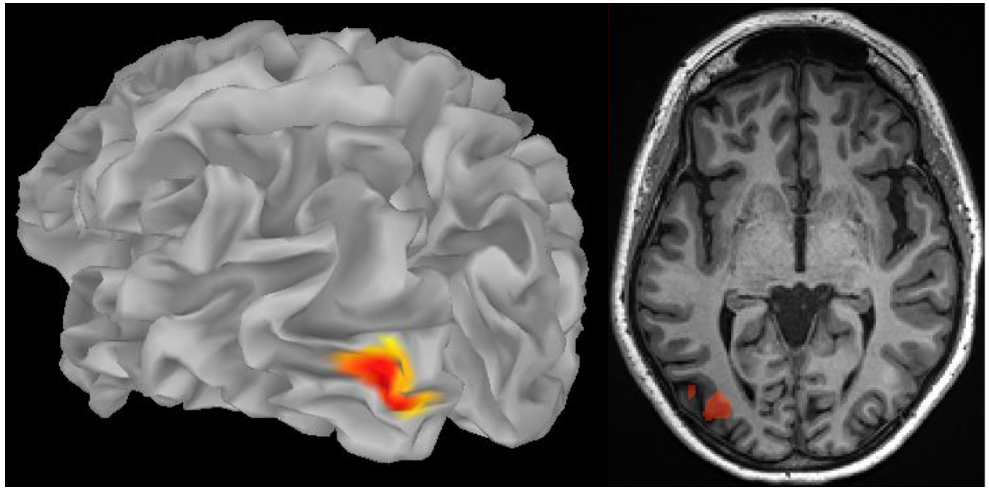

***Multimodal approach***

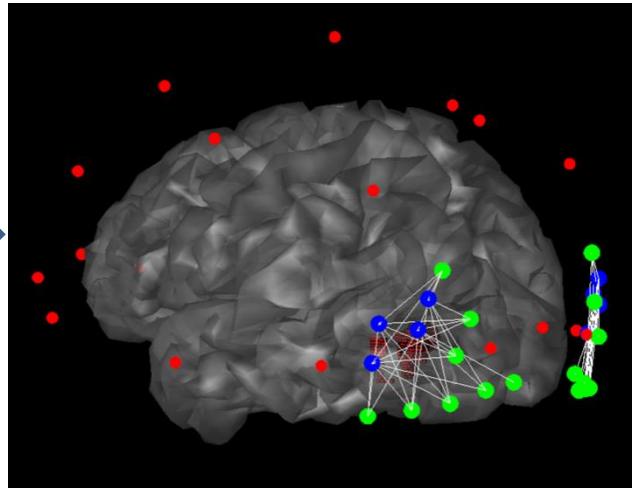
Features
- non-invasiveness
- **portability**
- **prolonged acquisitions**
- excellent time-resolution
- three-dimensional image reconstruction
- **potential for continuous bedside monitoring**
- **patients are not constrained**

**Courtesy of G. Pellegrino and Prof. C. Grova Lab, Biomedical Engineering Dpt and Neurology and Neurosurgery Dpt, McGill University, Montreal.**

Recruitment → Spatial Priors and ROI → Montage Planning → Neuronav and Montage → **EEG-NIRS** → Data Analysis → Great Ideas.

**MEG** **EEG** **Montage**





frontiers in Neuroscience

ORIGINAL RESEARCH
published: 22 March 2016
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## Hemodynamic Response to Interictal Epileptiform Discharges Addressed by Personalized EEG-fNIRS Recordings

*Giovanni Pellegrino[1*†], Alexis Machado[1†], Nicolas von Ellenrieder[1], Satsuki Watanabe[2], Jeffery A. Hall[2], Jean-Marc Lina[3,4,5], Eliane Kobayashi[2] and Christophe Grova[1,2,5,6]*



**Courtesy of G. Pellegrino and Prof. C. Grova Lab, Biomedical Engineering Dpt and Neurology and Neurosurgery Dpt, McGill University, Montreal.**


Grazie per l’attenzione