功能性近紅外光監測原理與應用
fNIRS — Principles and Applications

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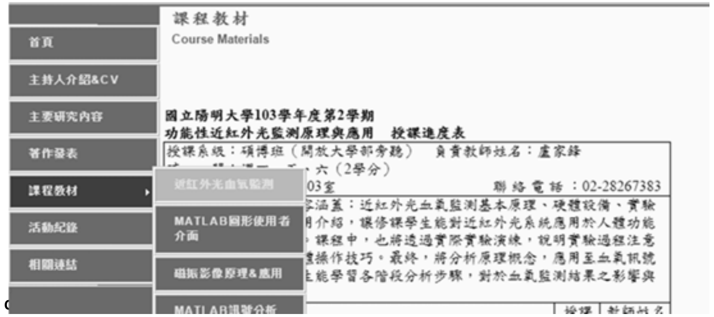
上課資料下載

- http://www.ym.edu.tw/~cflu
- 點選左欄 [**課程教材**] → [**近紅外光血氧監測**]
- 下載各週 [**課程講義**] **與** [**上課資料**] 、 [**課程影片**]



課程目標

- 透過本學期課程，修課學生能對於功能性近紅外光血氧監測(functional near-infrared spectroscopy, fNIRS)有一全面了解。
- 包含基本原理、儀器架構、實驗設計、操作技巧、訊號分析以及臨床研究應用。
- 旨在讓修課學生能有完整執行fNIRS實驗與分析資料的能力。

課程內容

- **近紅外光基本原理（1~6週）**
  - 組織交互作用、硬體設備、功能性研究、造影技術、假影與干擾
- **實驗設計與實作（7~10週）**
  - 空間分布、時間調控、刺激給予、安裝校正、品質監測與安全性
- **資料分析（11~14週）**
  - 分析軟體、檔案格式、訊號前處理、雜訊去除、事件分析
- **相關文獻與應用（15~16週）**
  - 腦功能研究、肌肉氧代謝

評分標準

- **出席率（20%）**：惟無故缺課達整學期三分之一以上，成績以不及格計算。
- **課堂參與度（20%）**：實驗實作與課程參與程度。
- **期末報告（60%）**：第17、18週，由修課學生針對與近紅外光血氧監測相關之研究議題或相關文獻，進行口頭報告，並繳交書面報告。

參考書目

- **Application of Near Infrared Spectroscopy in Biomedicine.** Thomas Jue, Kazumi Masuda. Springer, 2013.
  - Principles and instrumentation (chap 1), photo migration (chap 2~3), clinical applications (chap 4), muscle oxygenation (chap 5~7)
- **Infrared Spectroscopy - Life and Biomedical Sciences.** Edited by Theophile Theophanides. InTech, 2012.
  - Neurorehabilitation and behavorial science (chap 2~5), neuroscience (chap 7~10), BCI for rehabilitation (chap 19)
- Relevant theses and literatures (analysis methodology)

4/16、4/23調課

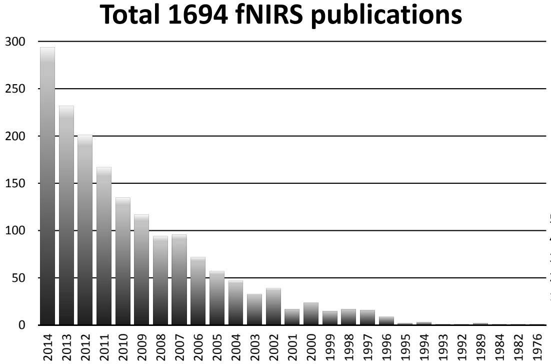
- **實驗設計：**
  - 空間分布、時間調控與任務刺激給予
- **實驗實作：**
  - 儀器校正與安裝技巧、訊號品質監測與安全性
- **4/9、4/30、5/7、5/14** 3小時課程

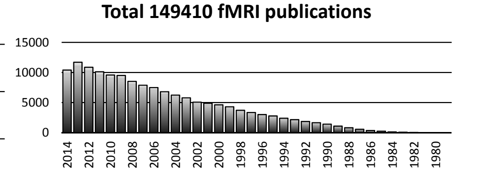
近紅外光課程總覽
Introduction

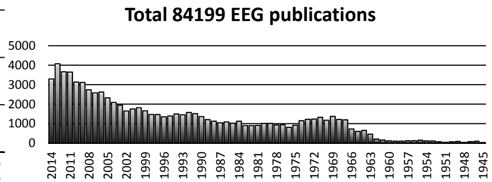
Course Map

Principles	Experiments	Analysis	Applications
• Photon migration • Instrumentation • waveform & imaging • Comparison with fMRI and EEG • Noise & artifects	• Study design • S-D arrangment • Task stimuli • Hardware setup • Experiment monitoring • Safety	• Data format • Software packages • Biophysiological noise • Motion artifact • Bad trial rejection • Event analysis • Statistics	• Neuroscience • Neurorehabilitation • Behavoral science • Muscle oxygenation • Clinical applications

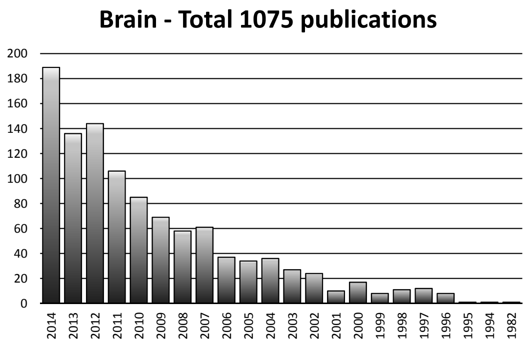
pubmed – fNIRS publications

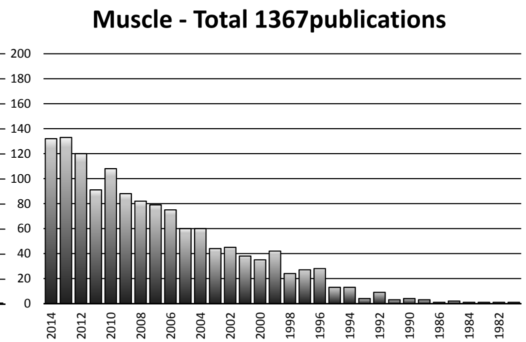


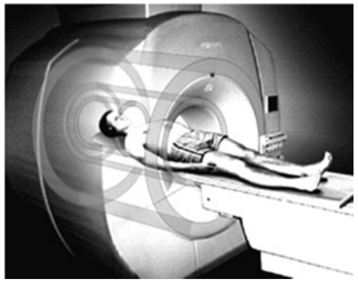




pubmed – fNIRS publications





EEG/MEG	fMRI	fNIRS
		
• **High temporal resolution** • **Neural activity** • Superficial cortex • **Open environment** • **Low cost** • **Wearable system** • Physiological/Electronic noise	• Low temporal resolution • BOLD signal • **Superficial & deep cortex** • Close environment • High cost • **High spatial resolution** • **High tissue contrast** • Magnetic and posture limitation	• **High temporal resolution** • Hemoglobin oxygenation • Superficial cortex • **Open environment** • **Low cost** • **Wearable system**

Multimodal comparison

Journal of Cerebral Blood Flow & Metabolism (1996) **16**, 817–826;

Simultaneous Recording of Cerebral Blood Oxygenation Changes During Human Brain Activation by Magnetic Resonance Imaging and Near-Infrared Spectroscopy

Andreas Kleinschmidt, Hellmuth Obrig, Martin Requardt, Klaus-Dietmar Merboldt, Ulrich Dirnagl, Arno Villringer and Jens Frahm

Med. Phys. 28 (4), April 2001

Investigation of human brain hemodynamics by simultaneous near-infrared spectroscopy and functional magnetic resonance imaging

Vladislav Toronov,[a] Andrew Webb, and Jee Hyun Choi
Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana-Champaign, 405 North Mathews, Urbana, Illinois 61801

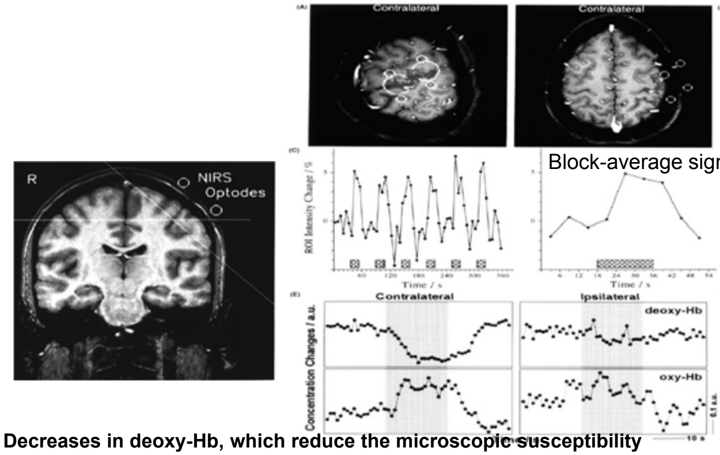
NeuroImage **17**, 719–731 (2002)

A Quantitative Comparison of Simultaneous BOLD fMRI and NIRS Recordings during Functional Brain Activation

Gary Strangman,*,†,‡ Joseph P. Culver,† John H. Thompson,† and David A. Boas†
*Neural Systems Group and †NMR Center, Massachusetts General Hospital-Harvard Medical School, and ‡Harvard-MIT Division of Health Sciences and Technology, Charlestown, Massachusetts 02129

fMRI vs. fNIRS

J CBF & Metabolism. 1996, 16:817-826.



- **Decreases in deoxy-Hb, which reduce the microscopic susceptibility effects, yield fMRI signal increases.**

Multimodal comparison

NeuroImage **16**, 587–592 (2002)

Simultaneous Recording of Event-Related Auditory Oddball Response Using Transcranial Near Infrared Optical Topography and Surface EEG

Richard P. Kennan,* Silvina G. Horovitz,† Atsushi Maki,‡ Yuichi Yamashita,‡ Hideaki Koizumi,‡ and John C. Gore†,§

Journal of Neuroscience Methods 204 (2012) 326–340

Clinical Neuroscience

Nonlinear hemodynamic responses in human epilepsy: A multimodal analysis with fNIRS-EEG and fMRI-EEG

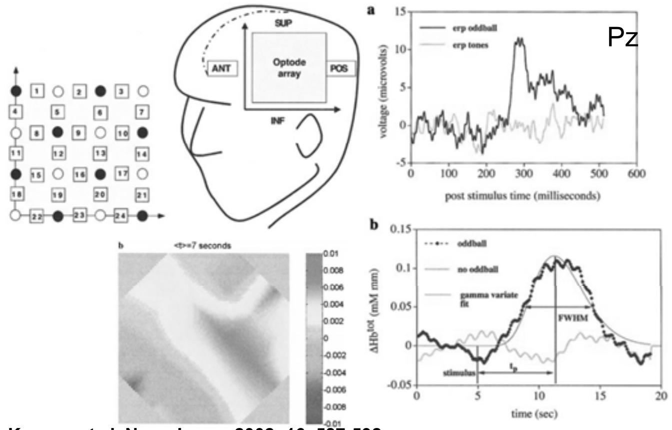
Philippe Pouliot[a,e,*], Julie Tremblay[b], Manon Robert[c], Phetsamone Vannasing[b], Franco Lepore[c], Maryse Lassonde[c,b], Mohamad Sawan[a], Dang Khoa Nguyen[d], Frédéric Lesage[a,e]

NeuroImage 85 (2014) 432–444

Cortical effects of user training in a motor imagery based brain–computer interface measured by fNIRS and EEG

Vera Kaiser[a,1], Günther Bauernfeind[a,*,1], Alex Kreilinger[a], Tobias Kaufmann[b], Andrea Kübler[b], Christa Neuper[a,c], Gernot R. Müller-Putz[a]

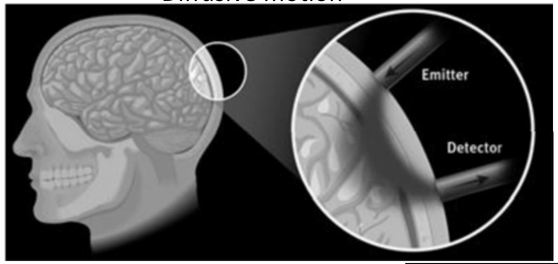
fNIRS vs. EEG

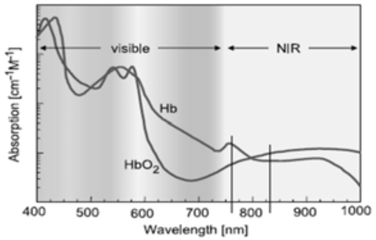


Kennan et al. NeuroImage 2002: 16, 587-592.

Tissue Migration and Absorption

Diffusive motion





$$\mu_{780nm} = \varepsilon_{HbO_2}(780nm) \times c_{HbO_2} + \varepsilon_{Hb}(780nm) \times c_{Hb}$$
$$\mu_{820nm} = \varepsilon_{HbO_2}(820nm) \times c_{HbO_2} + \varepsilon_{Hb}(820nm) \times c_{Hb}$$

fNIRS Instruments

< portable/movable >

ISS instrument

NIRx NIRScount

Hitachi ETG-7100 system

DYNOT system

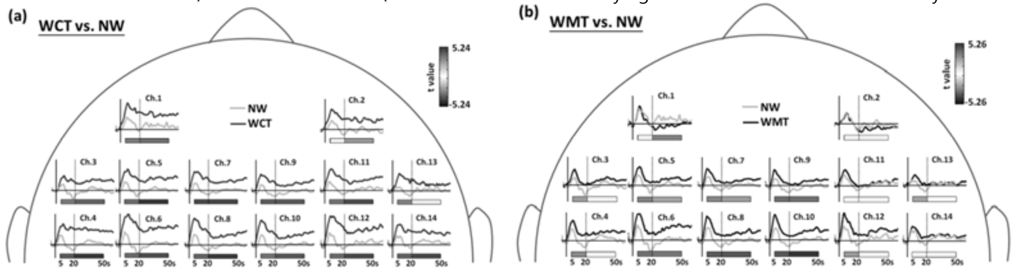
< wearable >

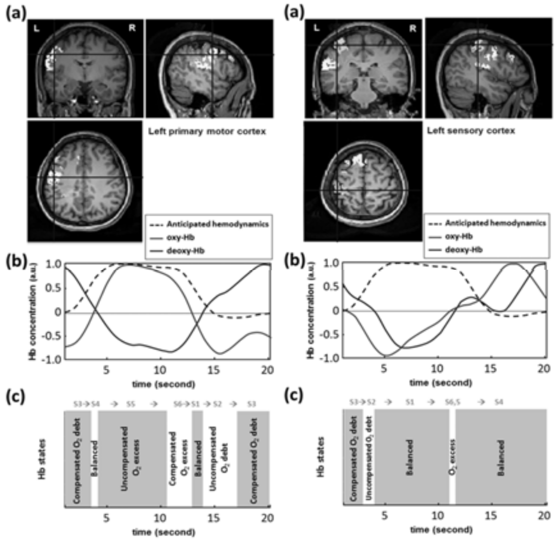
NIRSport

Size, Does it matter?

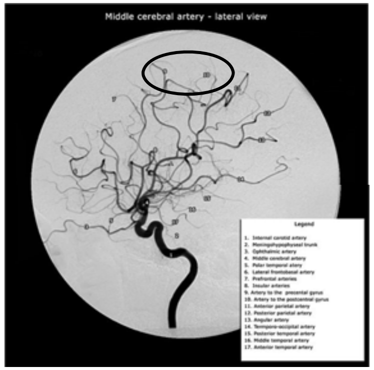
Walking dual-task

- **Walking while cognitive tasking (WCT)**
  - Walking on a walkway while serially subtracting 7 from an initial 3-digit number
- **Walking while motor tasking (WMT)**
  - Walking on the same walkway while carrying a 600-mL bottle of water on a tray.

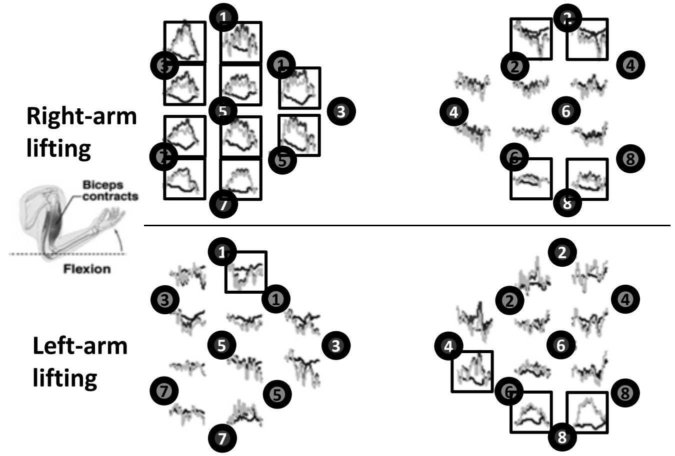




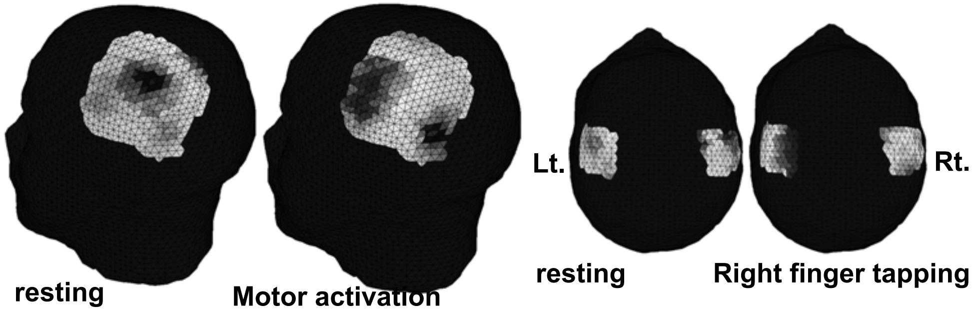
Resovle HbO/HbR



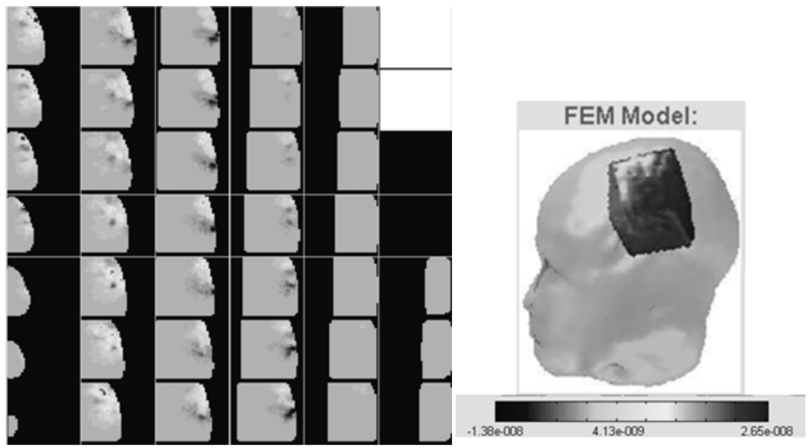
Bilateral Motor



fNIRS topography

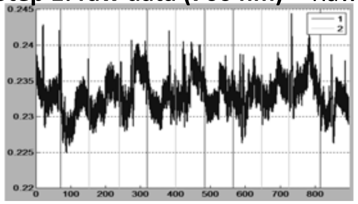


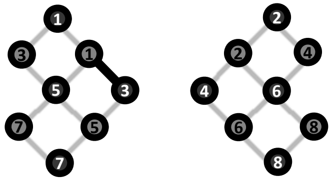
fNIRS tomography



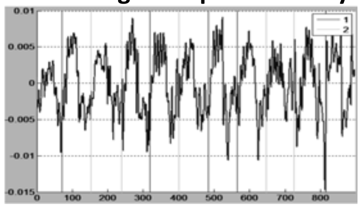
Signal Processing

Step 1: raw data (760 nm) Raw intensity → optical density → Hb concentration

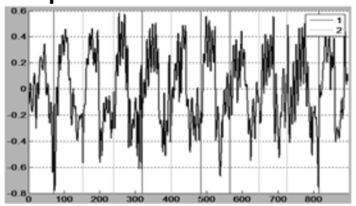




Step 2: filtering and optical density



Step 3: relative HbO concentration



Advanced motion correction

NeuroImage 85 (2014) 181–191

Motion artifacts in functional near-infrared spectroscopy: A comparison of motion correction techniques applied to real cognitive data

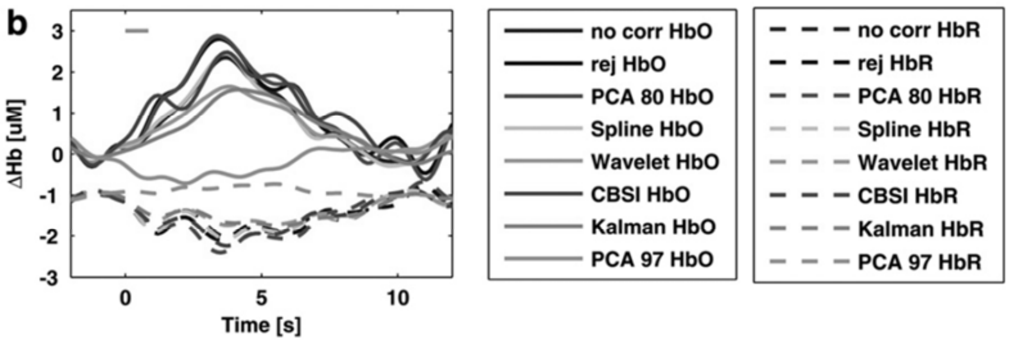
Sabrina Brigadoi [a,*], Lisa Ceccherini [a], Simone Cutini [b], Fabio Scarpa [a], Pietro Scatturin [a], Juliette Selb [c], Louis Gagnon [c], David A. Boas [c], Robert J. Cooper [d]

frontiers in NEUROSCIENCE — ORIGINAL RESEARCH ARTICLE, published: 11 October 2012, doi: 10.3389/fnins.2012.00147

A systematic comparison of motion artifact correction techniques for functional near-infrared spectroscopy

Robert J. Cooper[1], Juliette Selb[1], Louis Gagnon[1,2,3], Dorte Phillip[4], Henrik W. Schytz[4], Helle K. Iversen[4,5], Messoud Ashina[4] and David A. Boas[1]*

Motion correction



THE END

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