功能性近紅外光文獻選讀
fNIRS Journal Reading

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本週課程內容

- fNIRS Methodology
- fNIRS Lie detection
 - fNIRS-polygraph system

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fNIRS Methodology

Selected Articles

- [2014 NeuroImage] *Reconstructing functional near-infrared spectroscopy (fNIRS) signals impaired by* **extra-cranial confounds***: An easy-to-use filter method*

- [2012 NeuroImage] *Short separation channel location impacts the performance of short channel regression in NIRS*

Light Attenuation

- $\Delta OD = ln\left(\frac{I_e}{I_d}\right) = \Delta\mu_a\langle L\rangle$

- $\Delta OD = \Delta\mu_{a\,skin}\langle L_{skin}\rangle + \Delta\mu_{a\,GM}\langle L_{GM}\rangle$

- $\langle L_{skin}\rangle : \langle L_{GM}\rangle \approx 20:1$

- fNIRS is about twenty times more sensitive to SBF than to CBF (Haeussinger, PLoS One 2011).
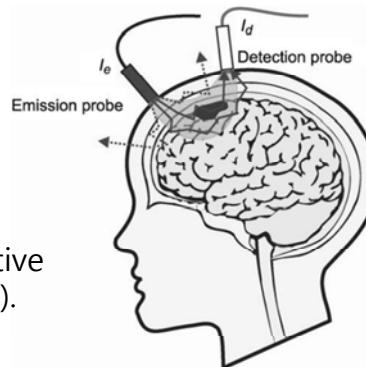
Light penetration

- Depend on scalp to cortex distance (SCD)

    Haeussinger, PLoS One 2011
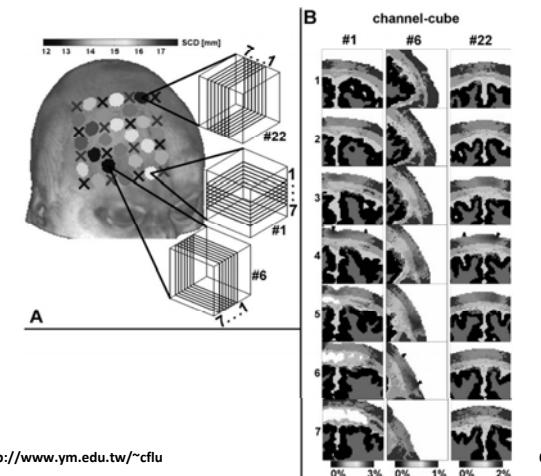
Influence of skin blood (1/2)

Mainly contributed from skin blood flow (SBF)

Influence of skin blood (1/2)

Residual (fitting FAR with NEAR)
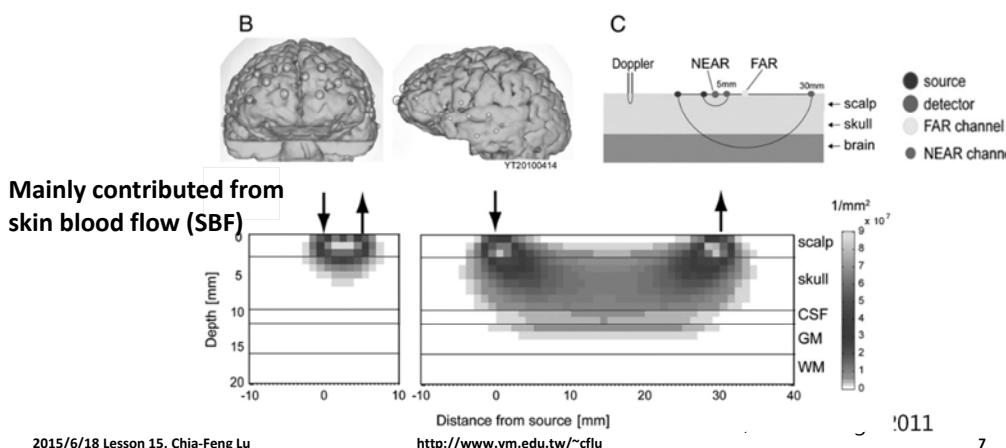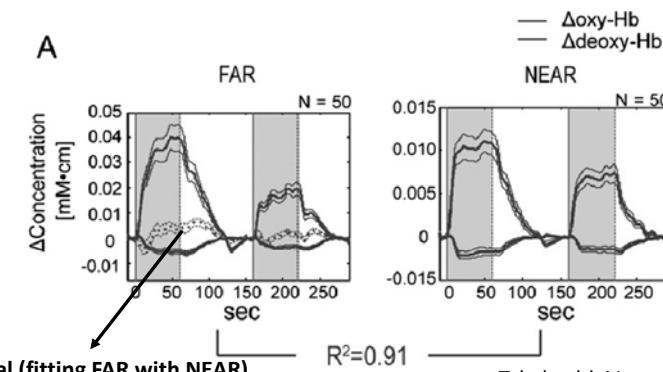
Takahashi, NeuroImage 2011

Time-resolved vs. continuous wave

- TRS mode
  - Shorter flight times → superficial tissues
  - Longer travel duration → brain tissue
- CWS mode
  - Needs skin flow correction

Aletti, Comput. Biol. Med. 2012
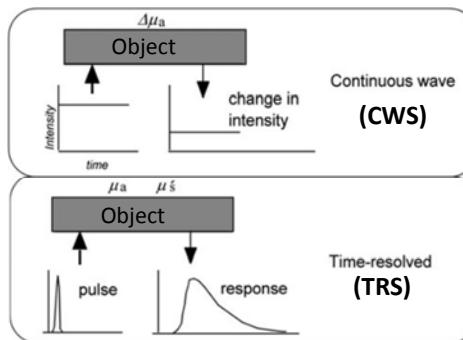
Correction of SBF in CW

- Include long and short emitter-detector distances per channel
  - Limited channel numbers
  - Fixed optode distance (usually 3.0 cm)

- Extra-cranial filter approach (only for HbO)
  - Subtract averaged HbO signal of channels with major extra-cranial contributions from the HbO time series of all channel.
 - HbR is hardly affected by SBF.   Kirilina, NeuroImage 2012
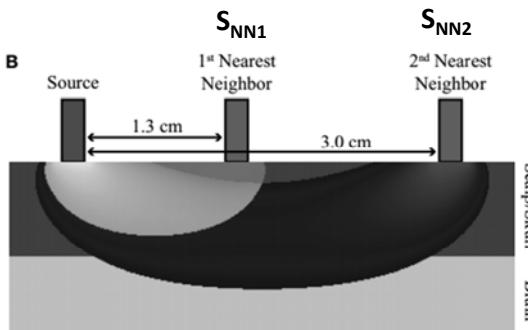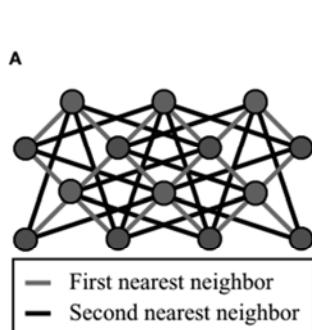
Short separation channels

Gregg, Frontiers in Neuroenergetics 2010

Superficial signal regression (SSR)

- $S_{NN2} = Sb_{rain} + Sn_{oise}$
- $S_{NN1} \approx Sn_{oise}$
  $= Ss_{uperficial} + Sg_{lobal}$

- Noise signal is produced by spatially averaging the SNN1.

- $y_{i\ brain} = y_i - \alpha_i y_n$
- $\alpha_i = \langle y_i, y_n \rangle / \langle y_n, y_n \rangle$
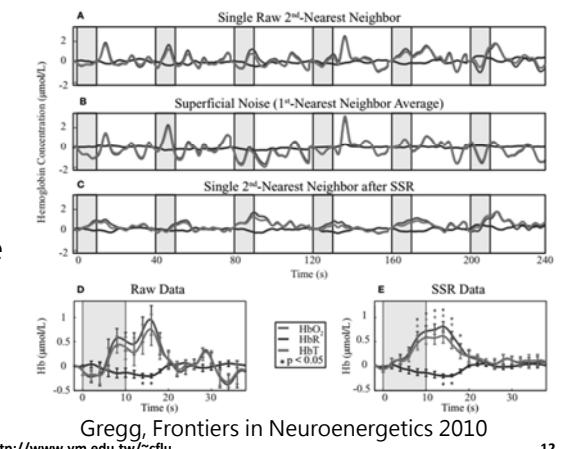

Gregg, Frontiers in Neuroenergetics 2010

Superficial signal regression (SSR)

Gregg, Frontiers in Neuroenergetics 2010
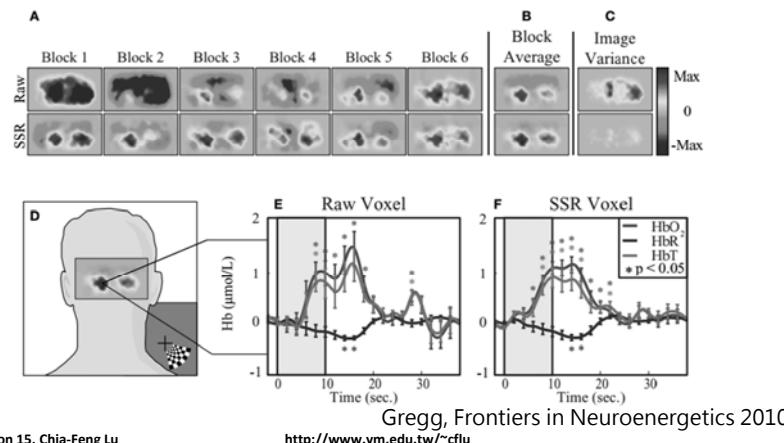
Short separation channels
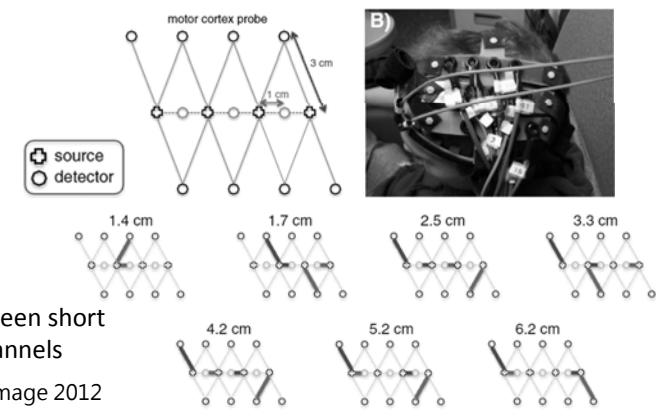
Possible distances between short and long separation channels

Gagnon, Neuroimage 2012

Effects of the relative distance
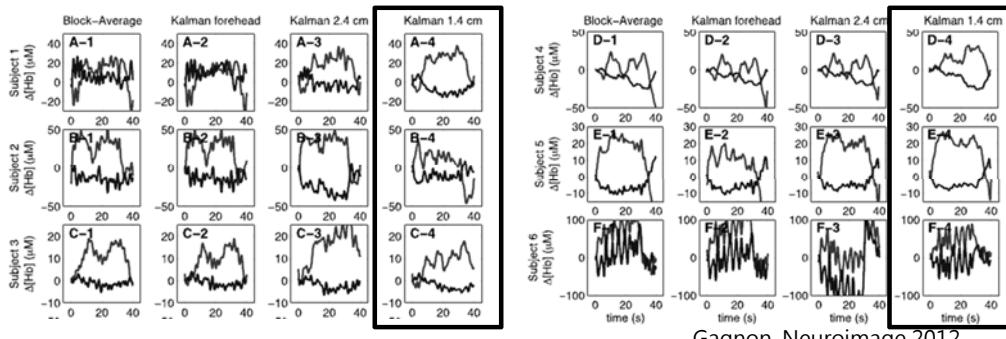
Gagnon, Neuroimage 2012

Major extra-cranial contributions

N-back task

Fronto-polar regions

temple regions

skin-BOLD ~ oxy-Hb correlations

Haeussinger, Neuroimage 2014
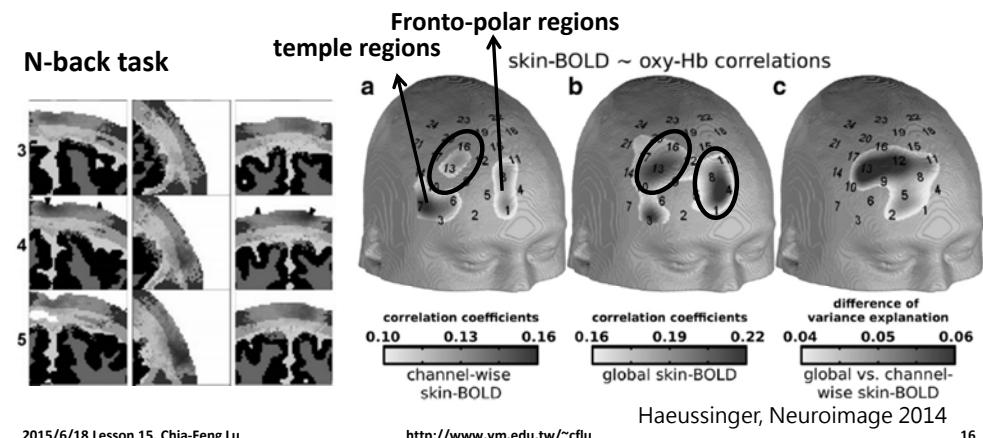
fNIRS/fMRI activation patterns

SBF-corrected

Haeussinger, Neuroimage 2014
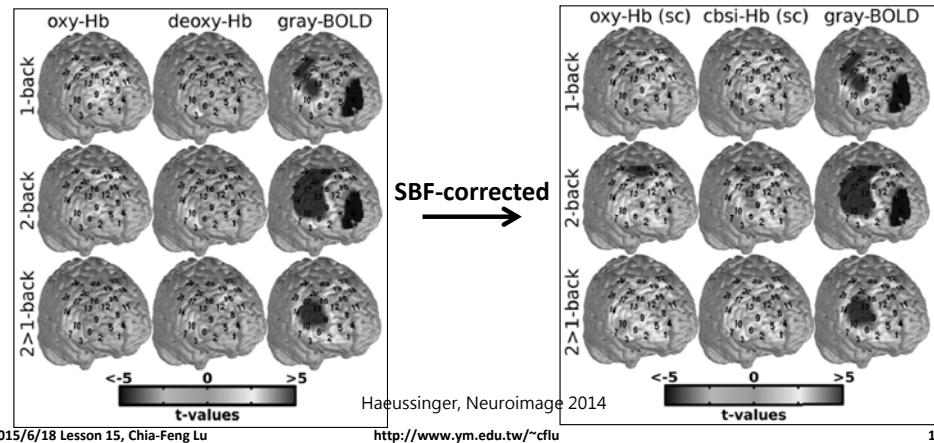
Skin correction

- Pros
  - Measure extra-cranial factors are measured directly.
  - No addition hardware is needed.
- Cons
  - Consume extra channels
  - Task-specific channels for extra-cranial signals

fNIRS Lie detection

Selected Articles

- [2015 frontiers in Psychology] *Single-trial lie detection using a combined fNIRS-polygraph system*

- [2009 Brain Research] *Functional near-infrared spectroscopy to investigate hemodynamic responses to deception in the prefrontal cortex*

Deception & polygraph

- Physiological changes
  - Respirations
  - Conduct electricity (EDA)
  - Cardio vascular activity
  - Occult body movements
- Complex neuronal activities
  - Lie center???

Polygraph data

Is he lying?
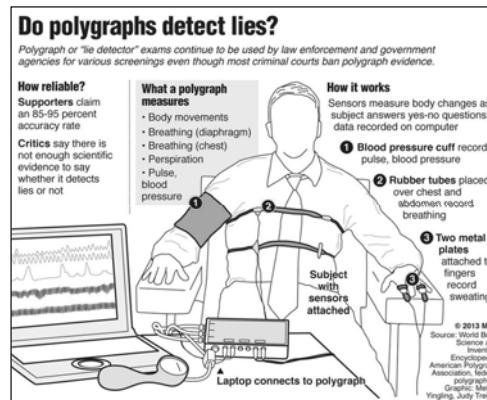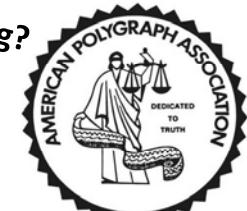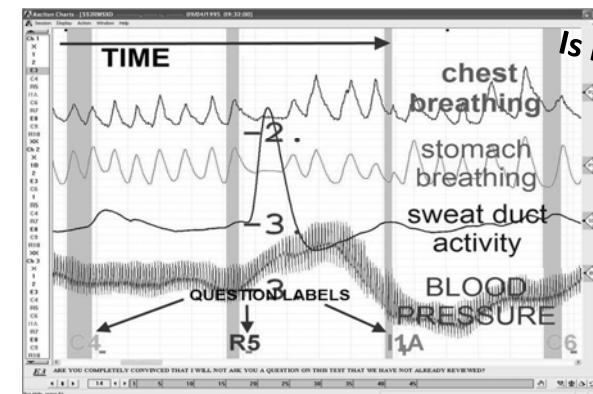
Axcition Systems, Inc.

fNIRS+polygraph

- Isolate and measure the brain activities.
- Deception-related hemodynamic response
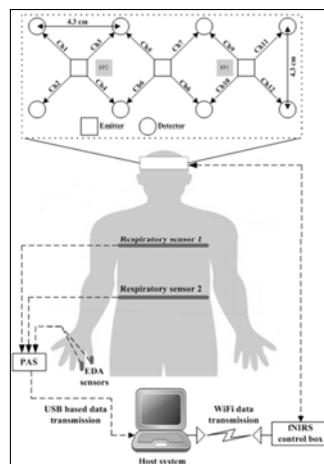
Bhutta, Frontiers in Psychology 2015

Mock theft scenario

- Subject is left alone in a room.
- Instructed to steal a watch or a ring.
- Taken to another room for questioning.

- The interrogator was unaware of the stolen thing.
- True/Lie questions.

Questions in protocol

"Neutral" Questions:
1. Do you like to swim?
2. Do you like to read?
3. Are you awake?
4. Are you asleep?
5. Are you under age 50?
6. Are you over age 18?

"Watch" Questions:
1. Did you take the watch from the drawer?
2. Is the watch in your locker?
3. Did you take the watch?
4. Did you steal the watch?
5. Was the watch stolen?
6. Did you hide the watch?

"Control" Questions:
1. Have you ever gossiped?
2. Have you ever done something illegal?
3. Have you ever done something immoral?
4. Have you used illegal drugs?
5. Have you ever deceived a loved one?
6. Have you ever made someone angry?

"Ring" Questions:
1. Did you take the ring from the drawer?
2. Is the ring in your locker?
3. Did you take the ring?
4. Did you steal the ring?
5. Was the ring stolen?
6. Did you hide the ring?

Experiment

- The subject was instructed clearly that he has to deny the possession of the stolen note and had to answer a lie for only the questions related to the stolen note.
- The neutral and control questions were asked just to keep the subject active.

L: lie
W: wait
C: control
N: neutral
T: true
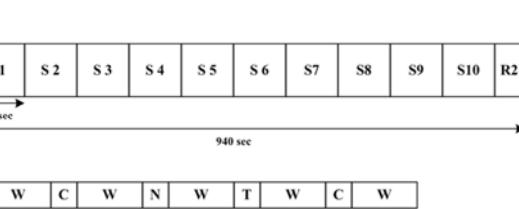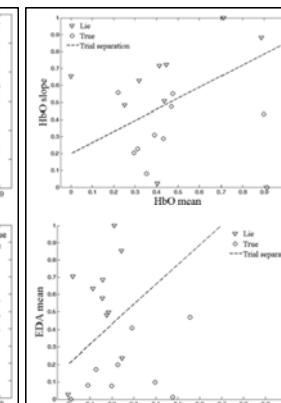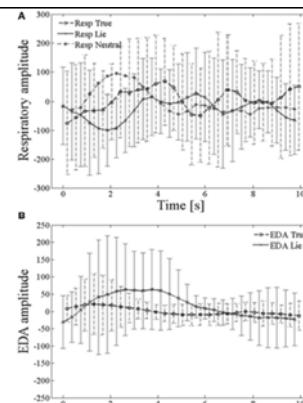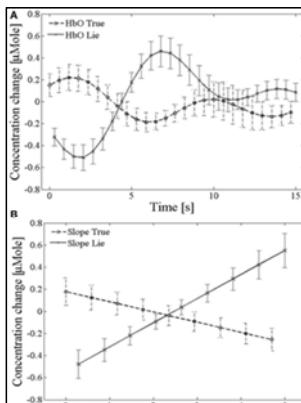
Bhutta, Frontiers in Psychology 2015

Results

Results

- The classification accuracy achieved by the combined system was much higher than those achieved by the single systems.
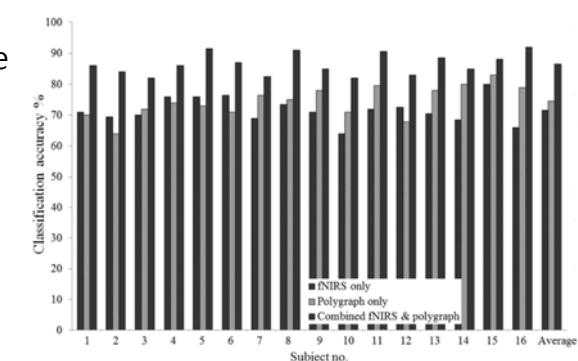
Potential of fNIRS

- Real-life lie-detection !?

THE END
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