fNIRS訊號處理流程

近紅外腦功能資料處理工作坊

http://www.ym.edu.tw/~cflu/CFLu_course_fnirsWorkshop.html

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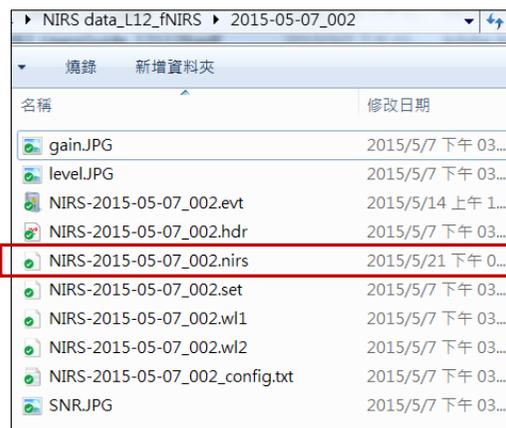National Yang-Ming University, Taipei, Taiwan, R.O.C
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講習內容安排

◦ 09:10~11:00 fNIRS原理簡介
◦ 10:10~11:00 fNIRS實驗設計
◦ 11:10~12:00 fNIRS探頭擺放設計與位置確認
◦ 12:00~13:30 用餐與休息
◦ 13:30~14:20 fNIRS實驗操作技巧
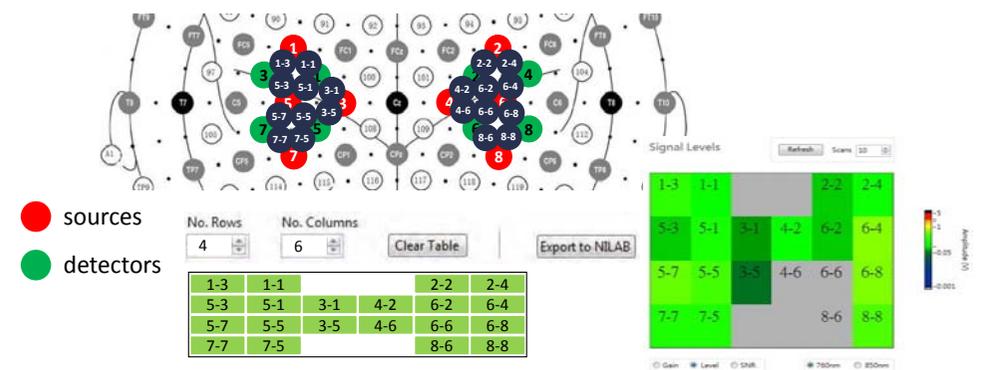◦ 14:30~15:20 fNIRS標準訊號處理流程
◦ 15:30~16:20 fNIRS數據結果呈現與相關性分析

Demo data

Recorded by NIRx NIRSport 88 model.
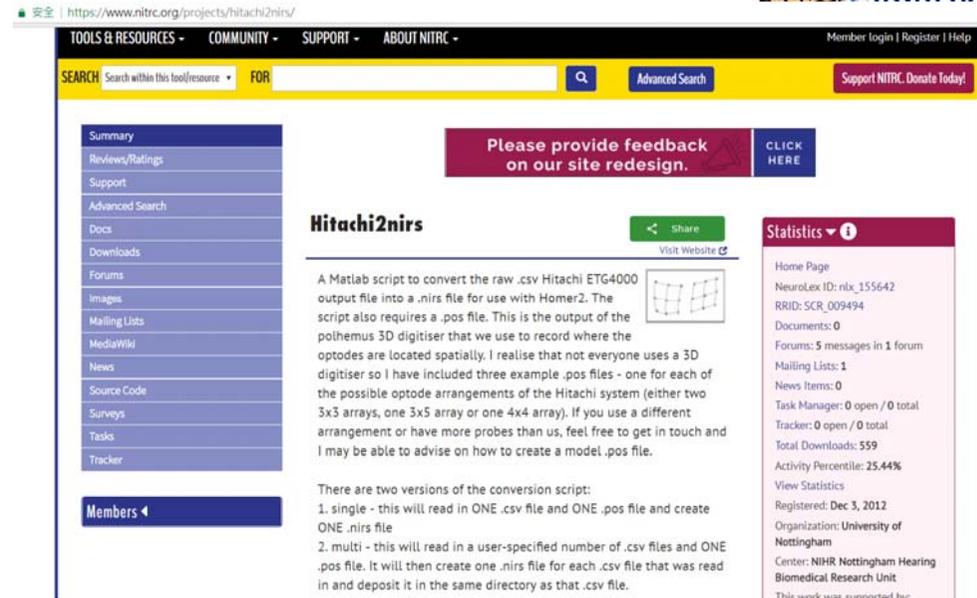

Bilateral Arm lifting

2015-05-07_002

sources
detectors

Slide 5

HOMER2 (*.nirs) Data Format

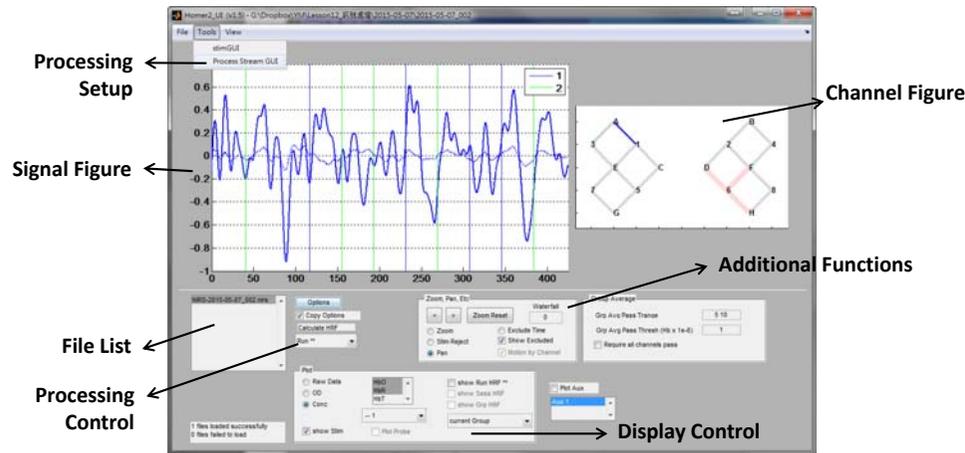**MATLAB mat-file format**

>> load('NIRS-2015-05-07_002.nirs','-mat')

SD: source/detector geometry
d: dual-wavelength raw signals for all channels
s: event time points
t: time axis in second
ml: lists of source-detector channels
aux: auxiliary signal

Workspace	
Name ▲	Value
SD	1x1 struct
aux	1655x1 double
d	1655x40 double
ml	40x4 double
s	1655x2 double
t	1655x1 double

Slide 6

https://www.nitrc.org/projects/homer2

Slide 7

Homer2_UI

Processing Setup
Signal Figure
Channel Figure
Additional Functions
File List
Processing Control
Display Control

Slide 8

procStreamGUI

Function Library (output, name, input)
Employed Function (output, name, input)
Function Description

Slide 1

ProcessOpt

Processing Control → Options

EasyNIRS_ProcessOpt

	Input Variable	**Parameters**
Intensity_to_OD		
Motion_Artifacts_By_Channel	tMotion	0.5
	tMask	1.0
	STDEVthresh	50.0
	AMPthresh	5.0
Spline_Motion_Correction	p	0.99
Bandpass_Filter	hpf	0.000
	lpf	3.00
OD_to_Conc	ppf	6.0 6.0
Block_Average	trange	-2.0 20.0

Function name

Slide 2
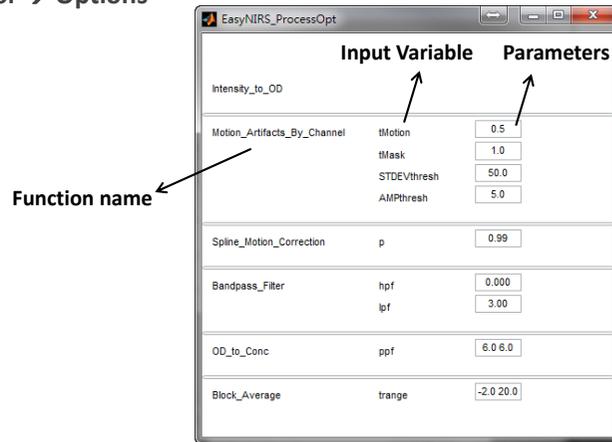
訊號處理流程
fNIRS signal processing

Slide 3

fNIRS Signal Processing Flow

- Visual Inspection on raw signal
- Channel/Trial CV Calculation
- Bad Channel/Trial removal
- Intensity to OD
- Motion detection
- Motion correction
- Bandpass filter
- OD to Concentration
- Block Average

Slide 4

Signals in S1-D1

Raw 760 nm (in V)

Time (second)

- Intensity to OD
- Bandpass filter
- OD to Conc
- Block Average (-5 30)
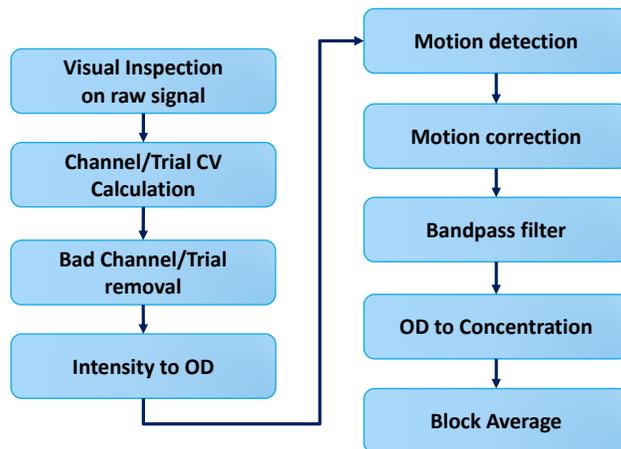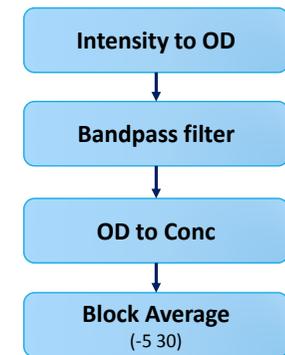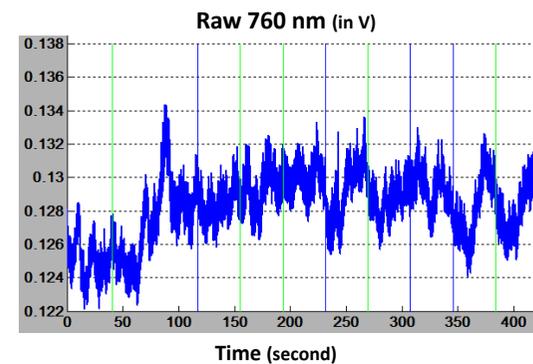
Effects of Bandpass filter

LPF = 2 Hz (cannot larger than 6.25/2 Hz)

LPF = 0.1 Hz

HPF = 0.01 Hz
LPF = 0.1 Hz

ΔHb

Block averages
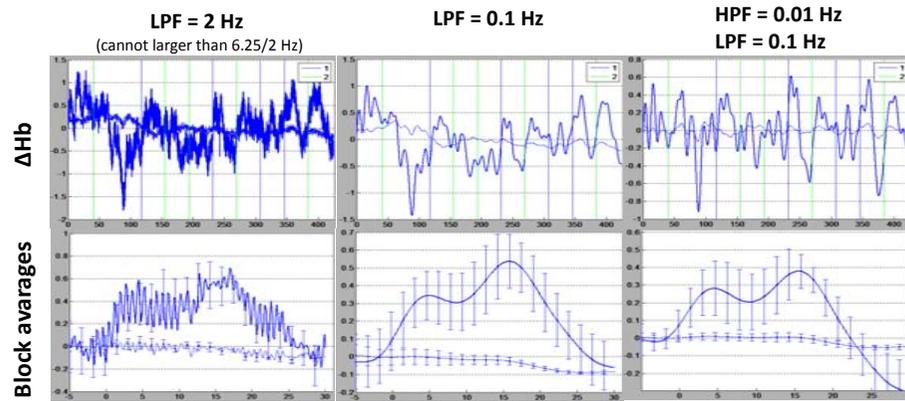
Tools ➜ Process Stream GUI
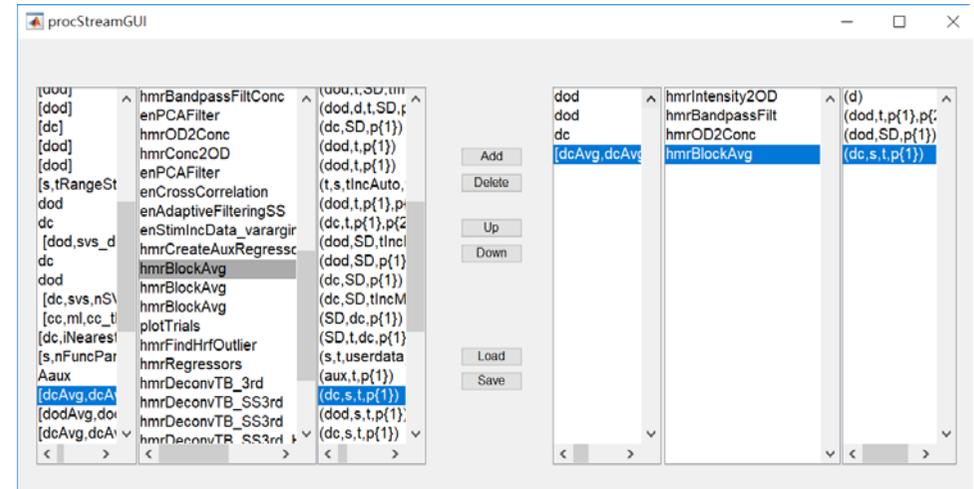
Without Motion corrections

Intensity to OD

Bandpass filter
(HPF = 0.01, LPF = 0.1)

OD to Conc

Block Average
(-5 30)

Block Averages

Right-arm

Left-arm

Signals in S1-D3

Raw 760 nm (in V)

ΔOD

ΔHbO & ΔHbR (in micro mole)

Time (second)

Time (second)

Time (second)

1: for right-arm
2: for left-arm
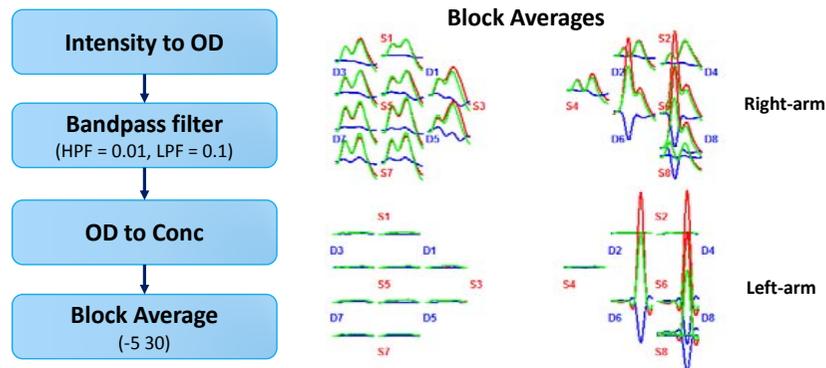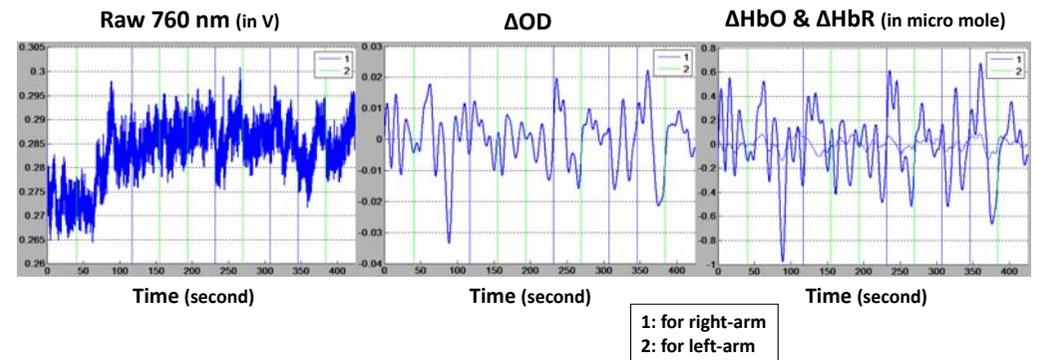
Motion artifacts in S6-D4

Raw 760 nm (in V)

ΔOD

ΔHbO & ΔHbR (in micro mole)

Time (second)

Time (second)

Time (second)

1: for right-arm
2: for left-arm

Visual Inspection

Bad signal quality ➔

Sufficient signal quality
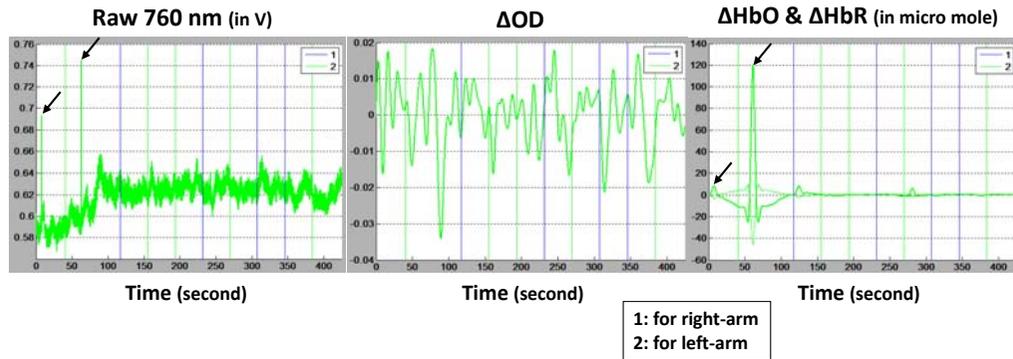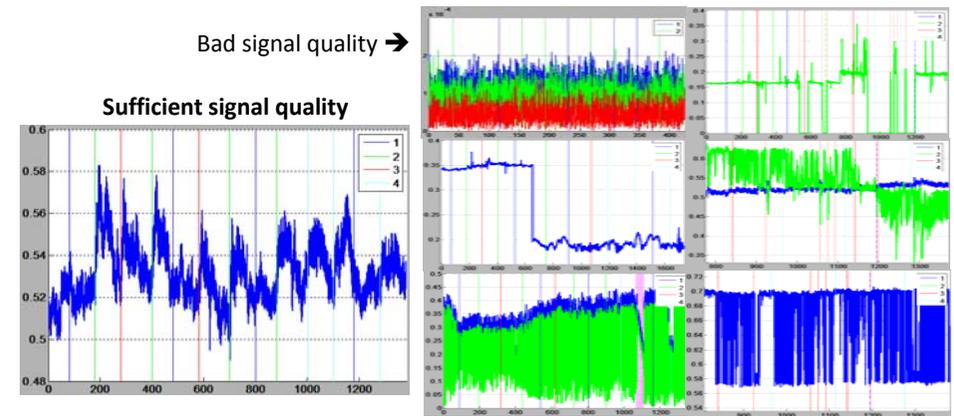
Channel/Trial CV

Coefficient of variation (CV)

◦ $CV = \frac{\sigma}{\mu} \times 100\%$

Channel CV (CV_{chan})
◦ Reject channels with CV_{chan} >15 %

Trial CV (CV_{trial})
◦ Reject trials with CV_{trial} >5~10 %

Run CalculateCV.m and select a data folder with HOMER files
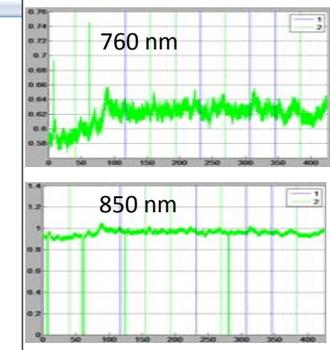
Piper et al., 2014.

CV in S6-D4

760 nm

850 nm

High CV in trial #1 at 850 nm !!

Bad Trial/Period Removal

- Intensity to OD
- Manually reject trials (Trials # 1, 2, and 6)
- Bandpass filter (HPF = 0.01, LPF = 0.1)
- OD to Conc
- Block Average (-5 30)

Block Averages

Right-arm

Left-arm
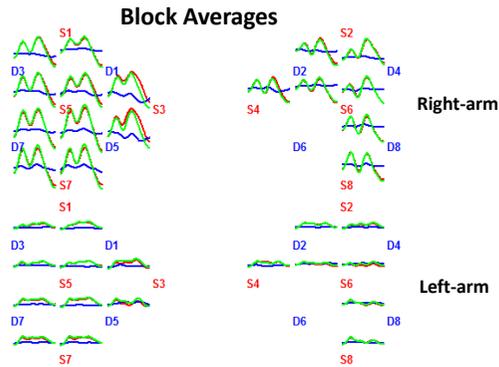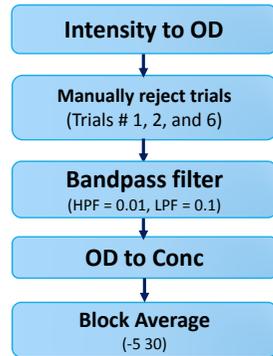
Post-processing Techniques

Spline interpolation   Scholkmann et al., 2010
- hmrMotionCorrectSpline.m

Principal component analysis (PCA)   Zhang et al., 2005
- hmrMotionCorrectPCA.m

Wavelet filtering   Molavi and Dumont, 2012
- hmrMotionCorrectWavelet.m

Correlation-based signal improvement (CBSI)   Cui et al., 2010
- hmrMotionCorrectCbsi

Corrected by Spline Correction

- Intensity to OD
- Motion Artifacts By Channel (0.5, 3.0, 10.0, 5.0)
- Spline Motion Correction (0.99)
- Bandpass filter (HPF = 0.01, LPF = 0.1)
- OD to Conc
- Block Average (-5 30)

Block Averages
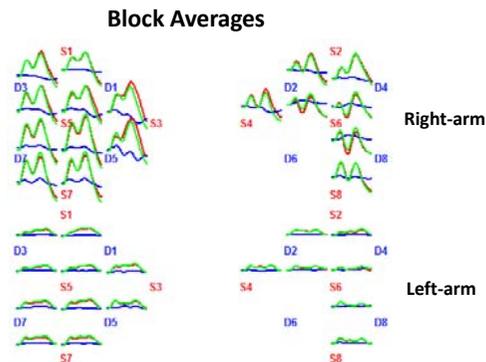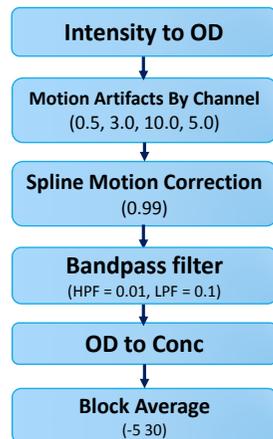
Right-arm

Left-arm

Spline Corrected Signals

Raw 850 nm (in V)   **ΔOD**   **ΔHbO & ΔHbR (in micro mole)**

Time (second)   Time (second)   Time (second)
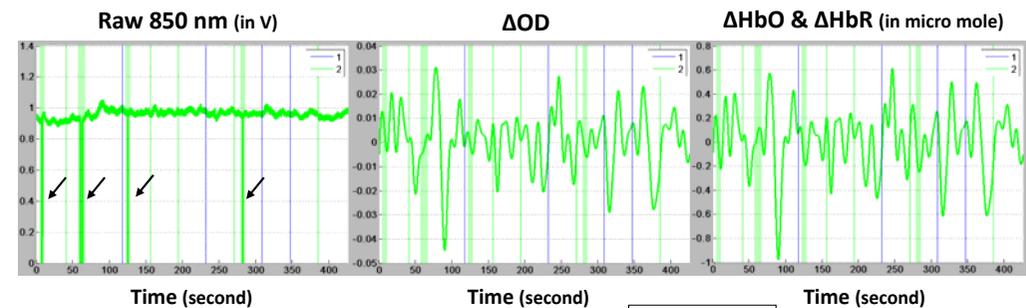
1: for right-arm
2: for left-arm

Recommended Processing Flows

Flow 1	Flow 2	Flow 3
Intensity to OD	**Intensity to OD**	**Intensity to OD**
Motion Artifacts By Channel (0.5, 3.0, 10.0, 5.0)	**Motion Artifacts By Channel** (0.5, 3.0, 10.0, 5.0)	⋮
PCA Motion Correction (0.8~0.97)	**Wavelet Motion Correction** (0.1~1.5)	**Bandpass filter** (HPF = 0.01, LPF = 0.1)
Bandpass filter (HPF = 0.01, LPF = 0.1)	**Bandpass filter** (HPF = 0.01, LPF = 0.1)	**OD to Conc**
OD to Conc	**OD to Conc**	**Cbsi Motion Correction** (0)
Block Average (-5 30)	**Block Average** (-5 30)	**Block Average** (-5 30)

盧家鋒 **Chia-Feng Lu, PhD**

Q & A

Thanks for your attention :)