陽明交大
NYCU

NBA
Laboratory of Neuroimage Biomarker Analysis

fNIRS-GLM&基礎統計分析

教育訓練工作坊

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

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講習內容安排

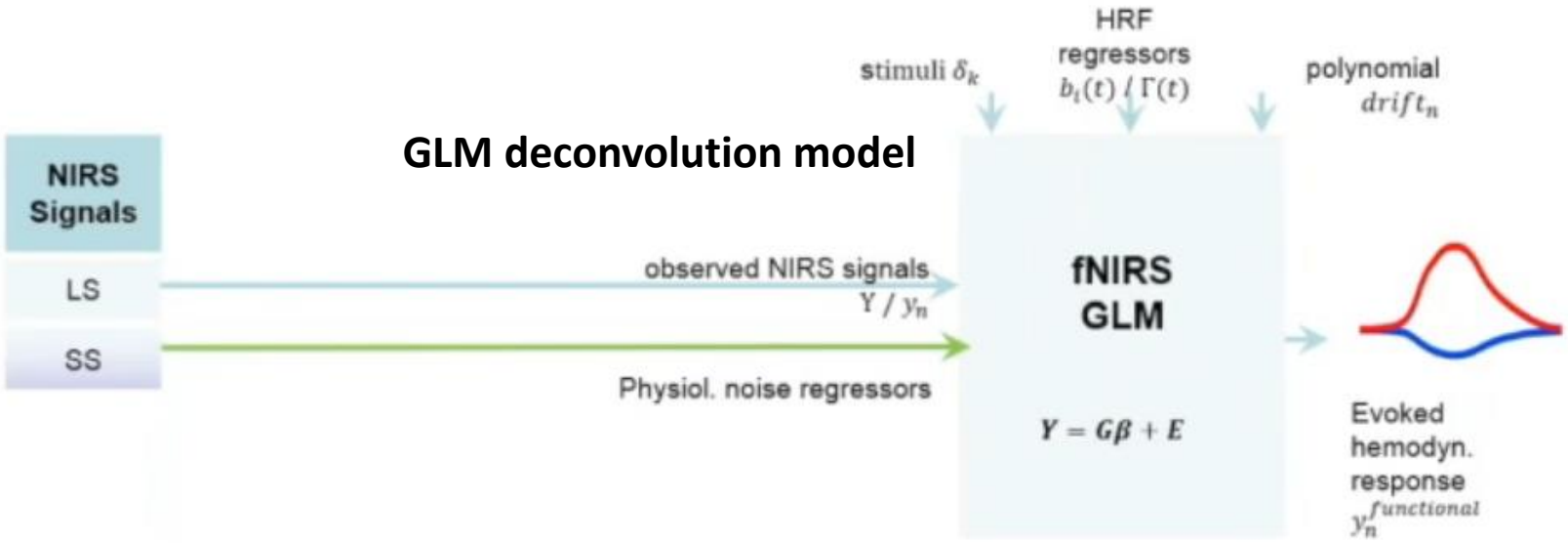
- 9:00~10:20 fNIRS原理簡介&實驗設計
- 10:30~12:00 NIRSport2硬體介紹&操作
- 12:00~13:30 用餐與休息
- 13:30 ~14:50 Homer 3訊號處理
- **15:10~16:00 GLM&基礎統計分析**

GLM with SS regression

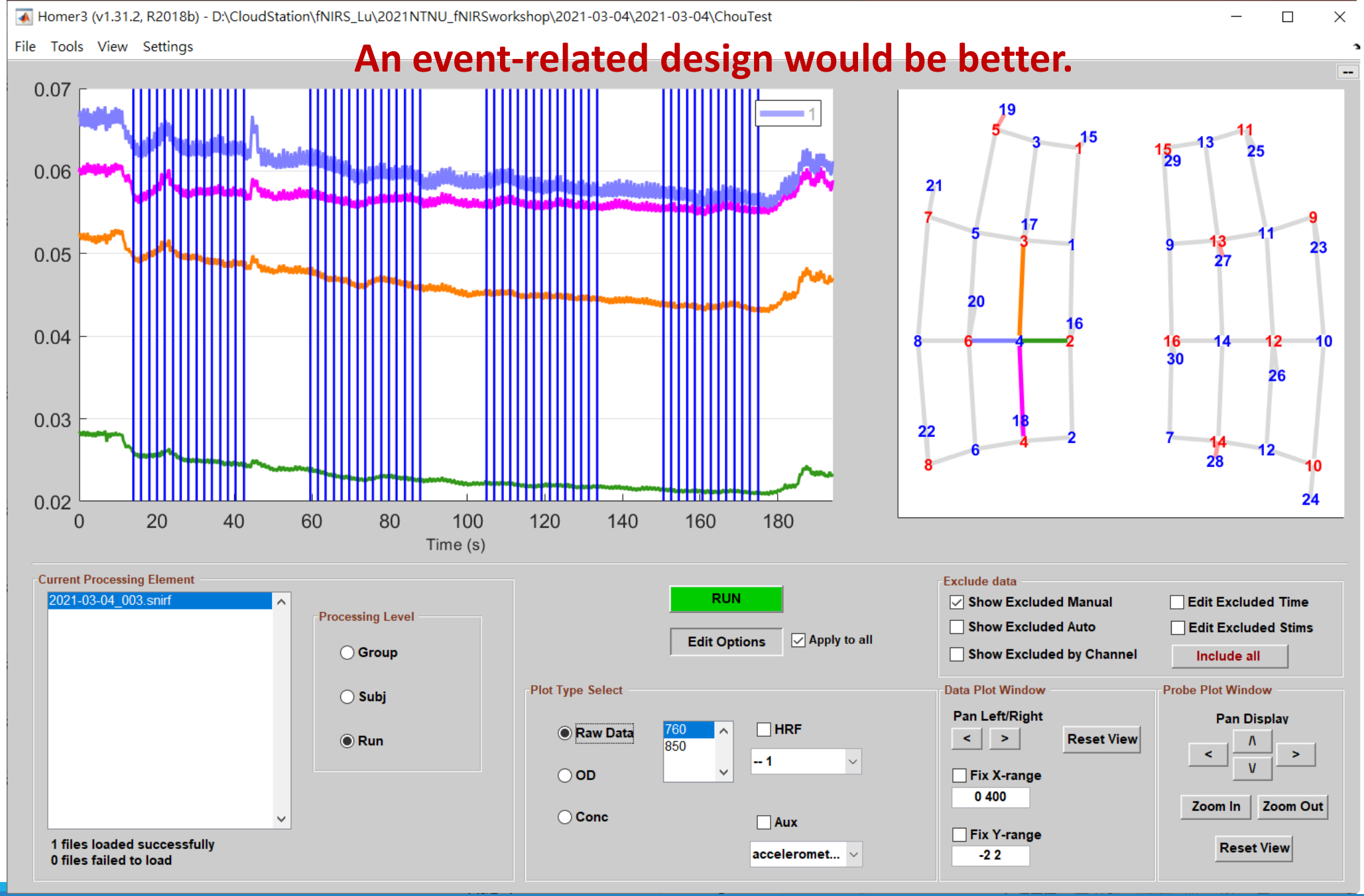
Improve signal quality

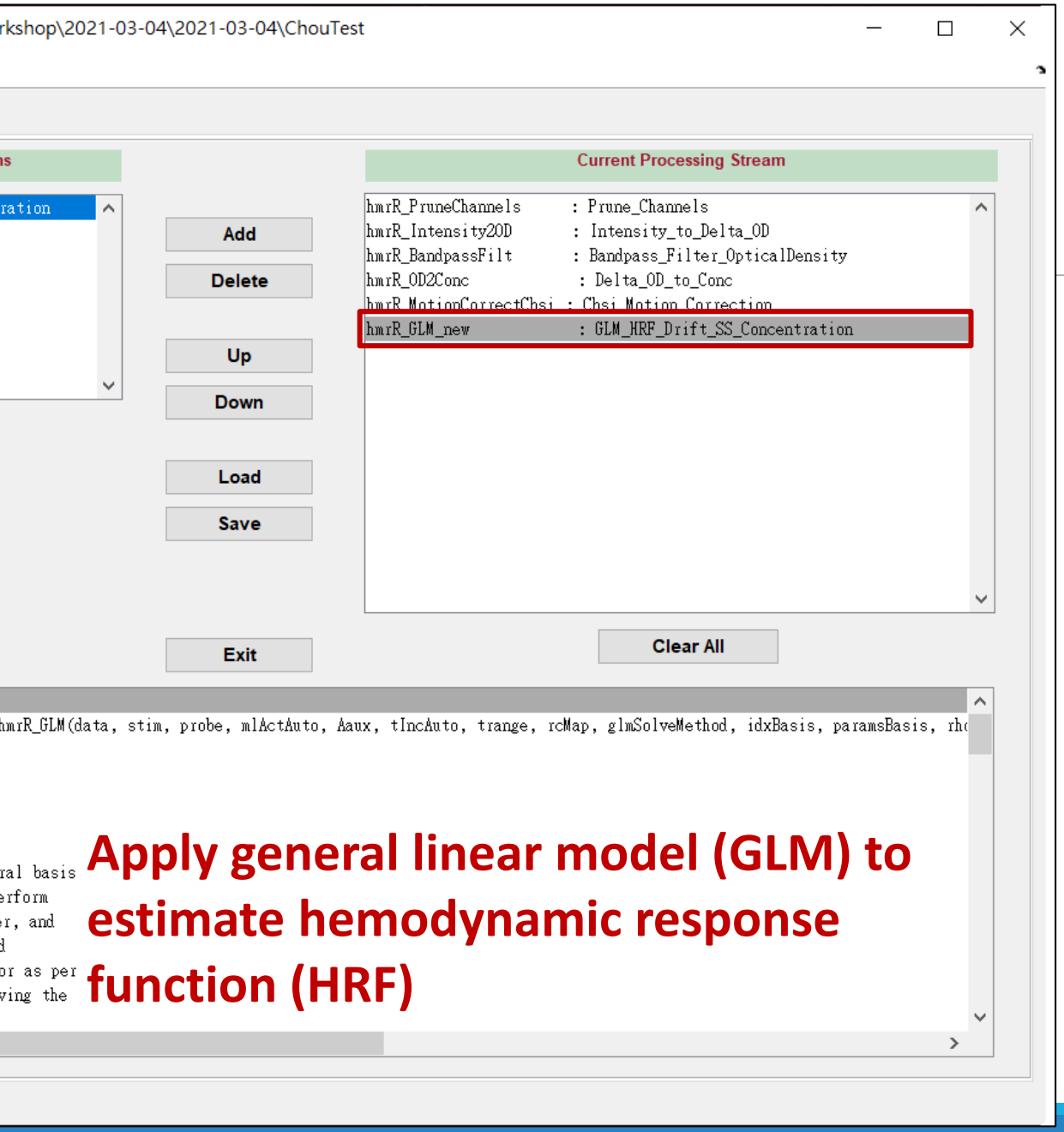
Eliminate confounding noise

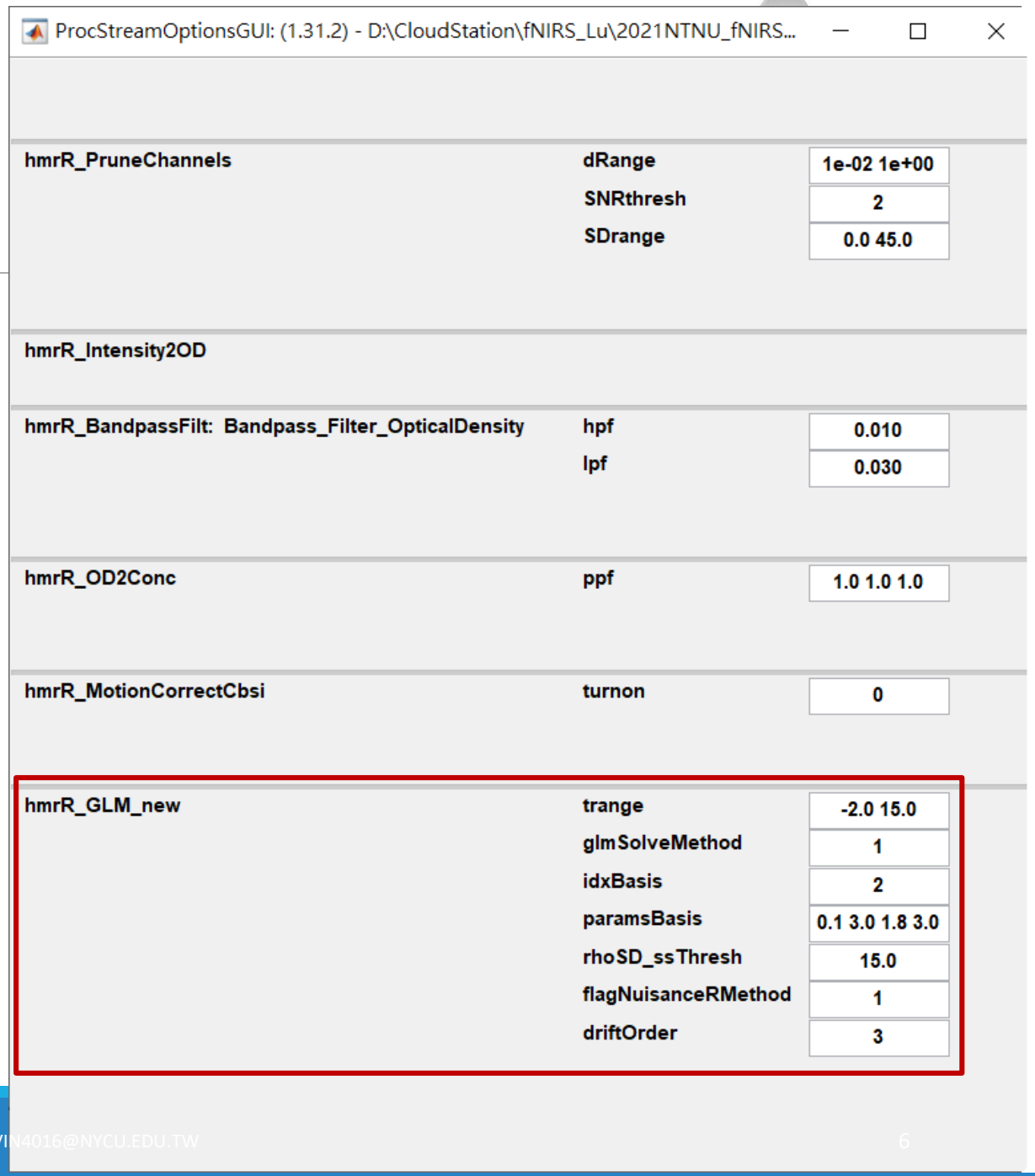
Systemic physiology and **motion-induced artifacts** represent two major sources of confounding noise in functional near infrared spectroscopy (fNIRS) that can inflate false positive rates (i.e., type I errors) of detecting evoked hemodynamic responses.



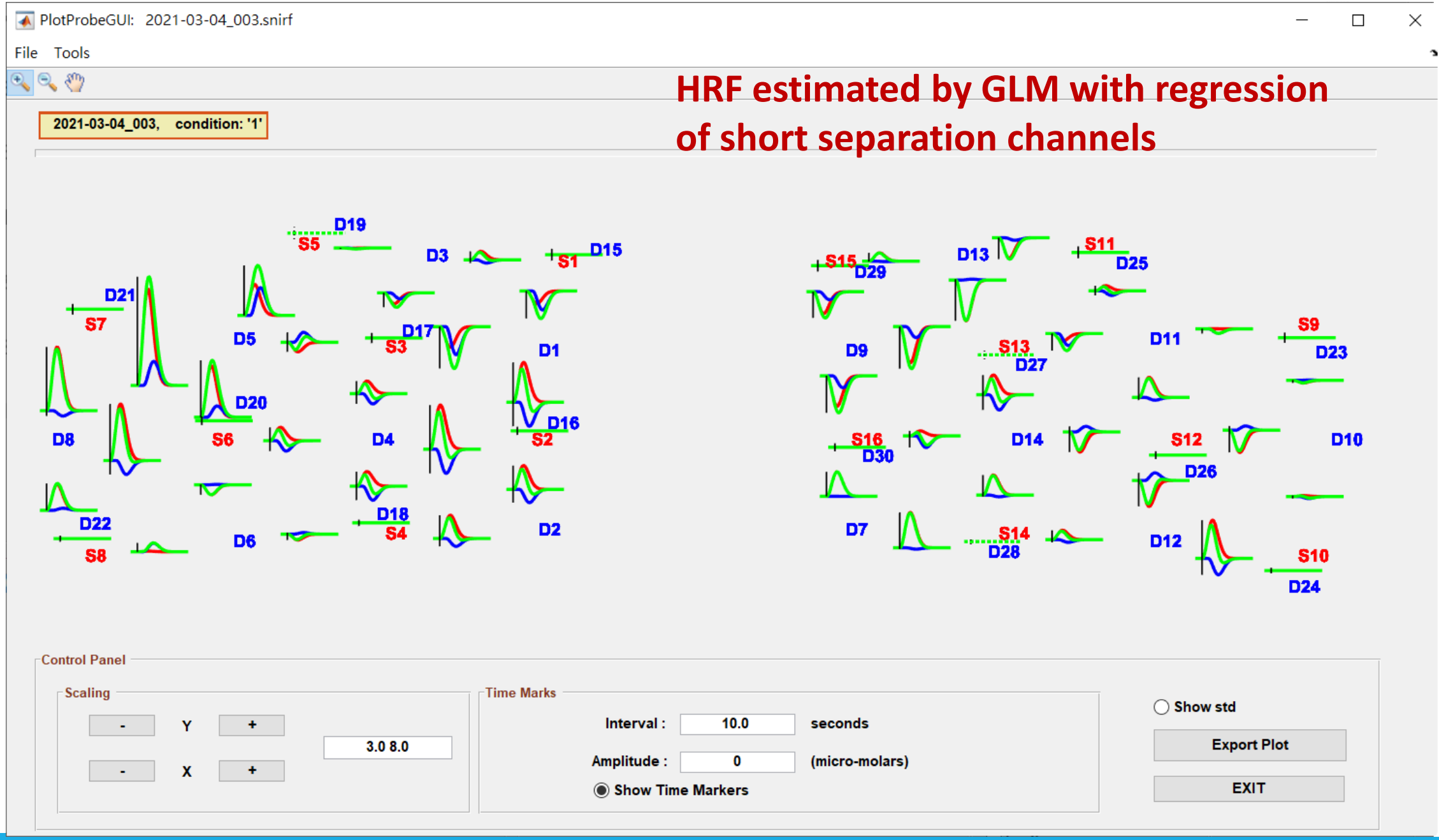
An event-related design would be better.



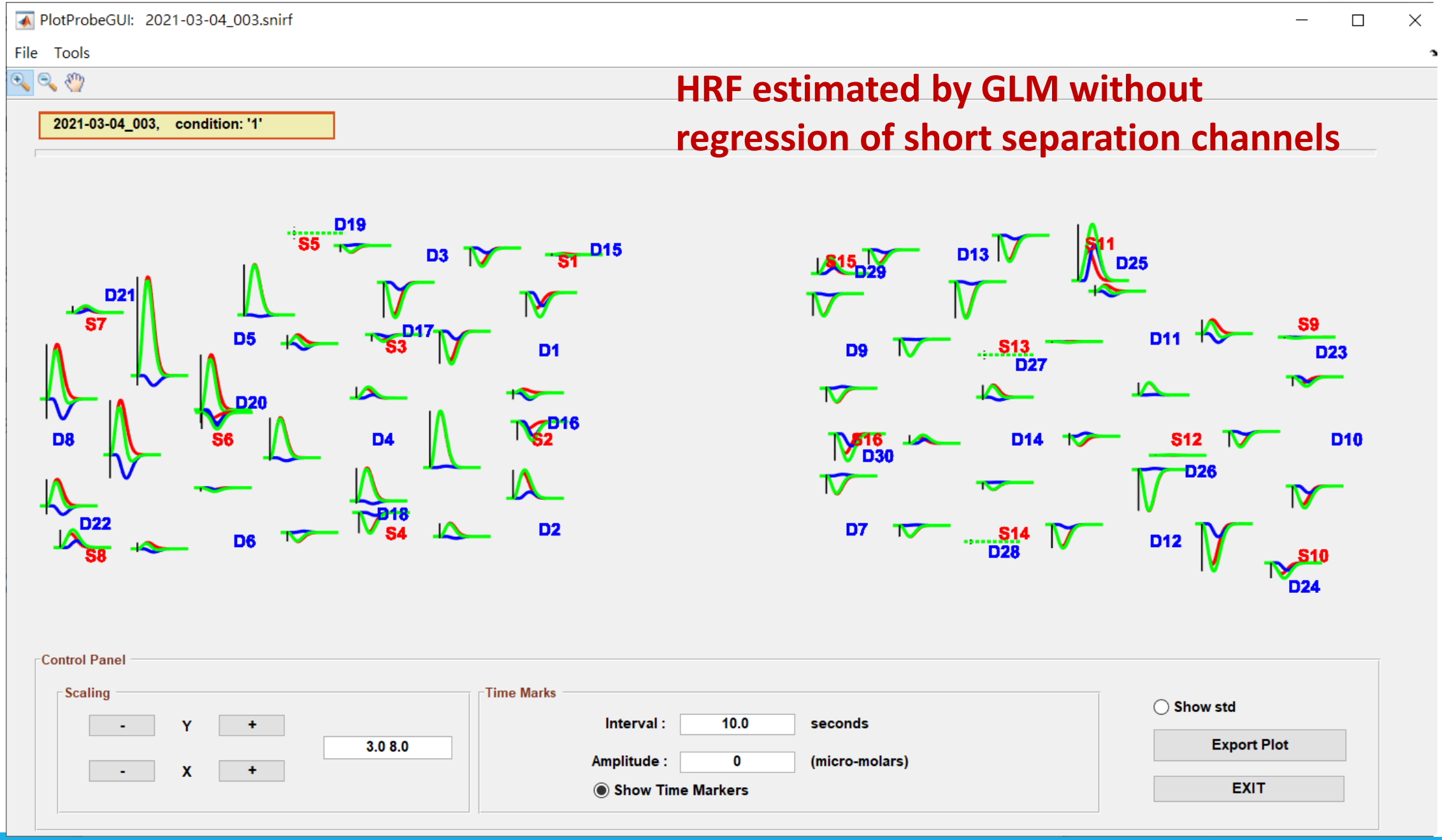

rkshop\2021-03-04\2021-03-04\ChouTest
Current Processing Stream
hmrR_PruneChannels : Prune_Channels
hmrR_Intensity2OD : Intensity_to_Delta_OD
hmrR_BandpassFilt : Bandpass_Filter_OpticalDensity
hmrR_OD2Conc : Delta_OD_to_Conc
hmrR_MotionCorrectCbsi : Cbsi_Motion_Correction
hmrR_GLM_new : GLM_HRF_Drift_SS_Concentration
Add
Delete
Up
Down
Load
Save
Exit
Clear All
hmrR_GLM(data, stim, probe, mlActAuto, Aaux, tIncAuto, trange, rcMap, glmSolveMethod, idxBasis, paramsBasis, rho
Apply general linear model (GLM) to estimate hemodynamic response function (HRF)


ProcStreamOptionsGUI: (1.31.2) - D:\CloudStation\fNIRS_Lu\2021NTNU_fNIRS...
hmrR_PruneChannels
dRange 1e-02 1e+00
SNRthresh 2
SDrange 0.0 45.0
hmrR_Intensity2OD
hmrR_BandpassFilt: Bandpass_Filter_OpticalDensity
hpf 0.010
lpf 0.030
hmrR_OD2Conc
ppf 1.0 1.0 1.0
hmrR_MotionCorrectCbsi
turnon 0
hmrR_GLM_new
trange -2.0 15.0
glmSolveMethod 1
idxBasis 2
paramsBasis 0.1 3.0 1.8 3.0
rhoSD_ssThresh 15.0
flagNuisanceRMethod 1
driftOrder 3

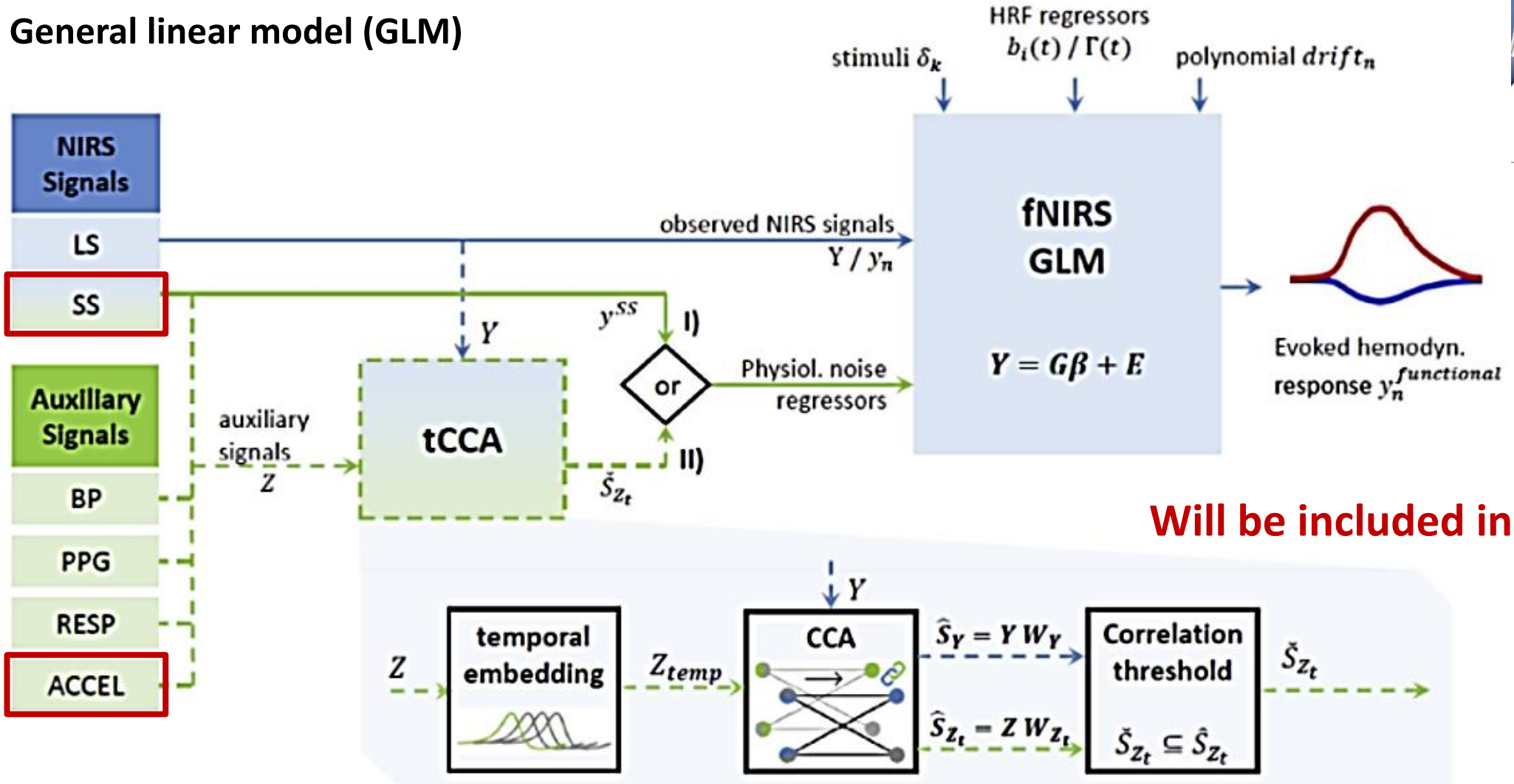
HRF estimated by GLM with regression of short separation channels



HRF estimated by GLM without regression of short separation channels



General linear model (GLM)



Will be included in Homer3.

Canonical Correlation Analysis (CCA)

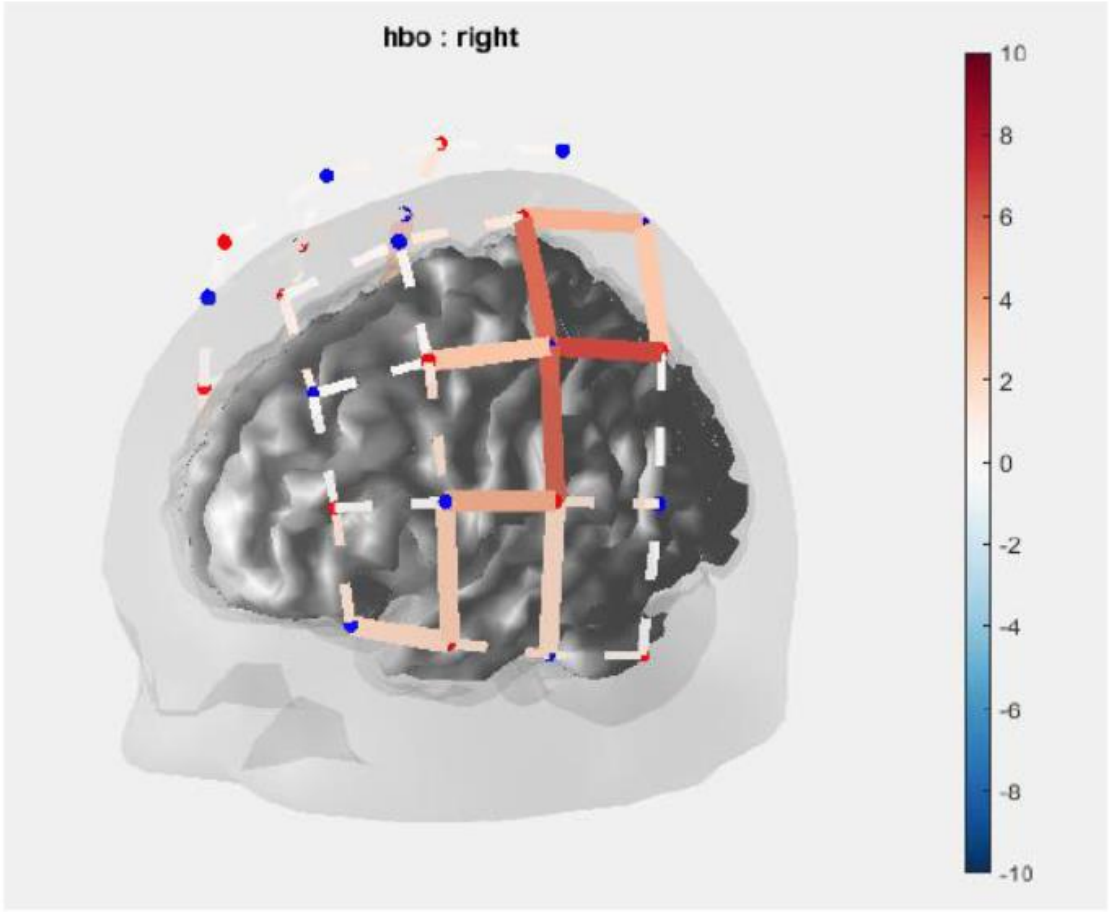
Luhmann et al. NeuroImage 208 (2020)

NIRS/Brain AnalyzIR Toolbox

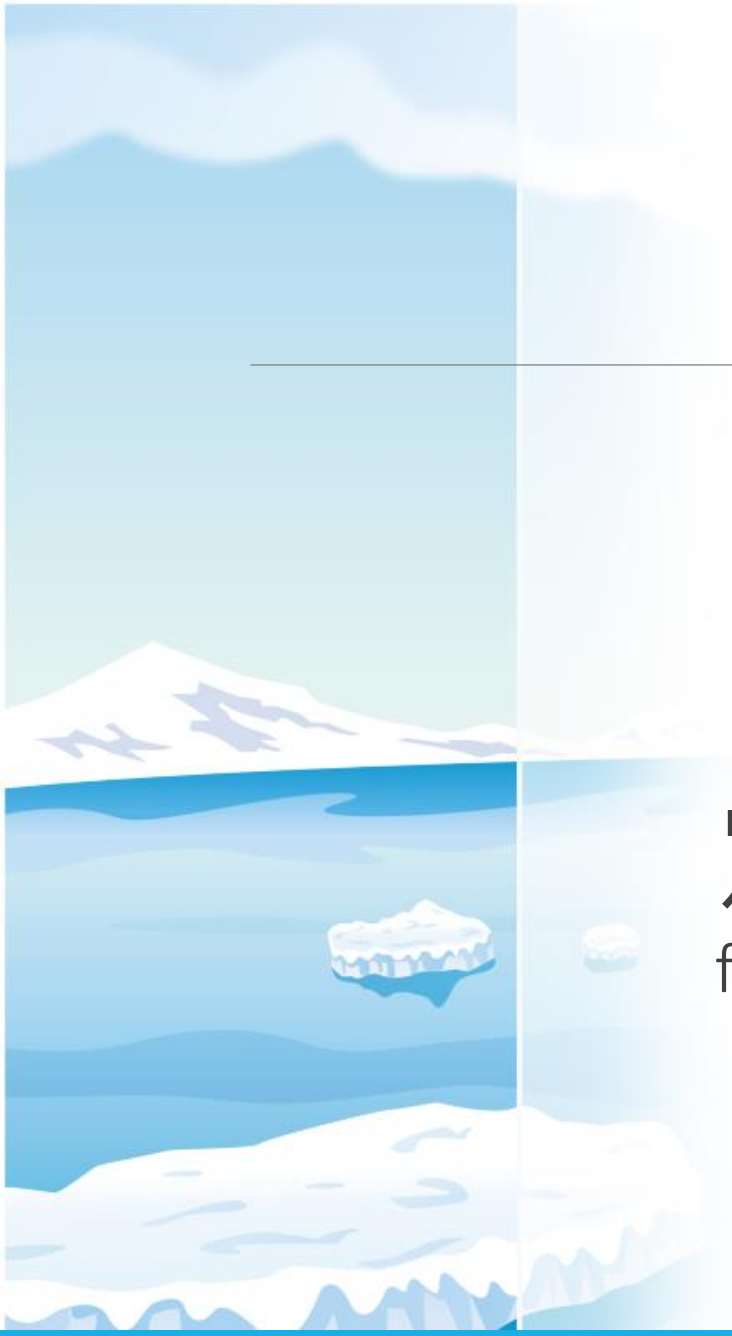
https://bitbucket.org/huppertt/nirs-toolbox/wiki/Home

https://nirx.net/webinars

- Created by Dr. Ted Huppert & team
  - Supported & Updated
- Can pull from other programs
  - Homer2, NIRS-SPM, FieldTrip
- Extremely versatile
- Many different analysis options
  - GLM with pre-whitening
  - Functional connectivity
  - Image reconstruction
  - Subject & group analysis
  - Integrates data from other modalities (MRI, EEG)



Santosa H, Zhai X, Fishburn F, Huppert T. The NIRS brain AnalyzIR toolbox. Algorithms. 2018 May;11(5):73.



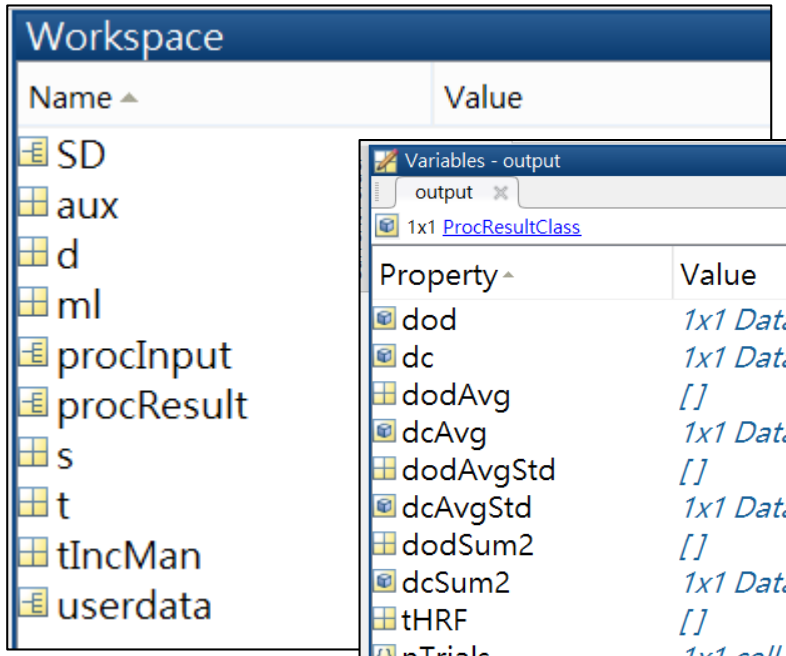
定量分析

fNIRS Quantitative Analysis

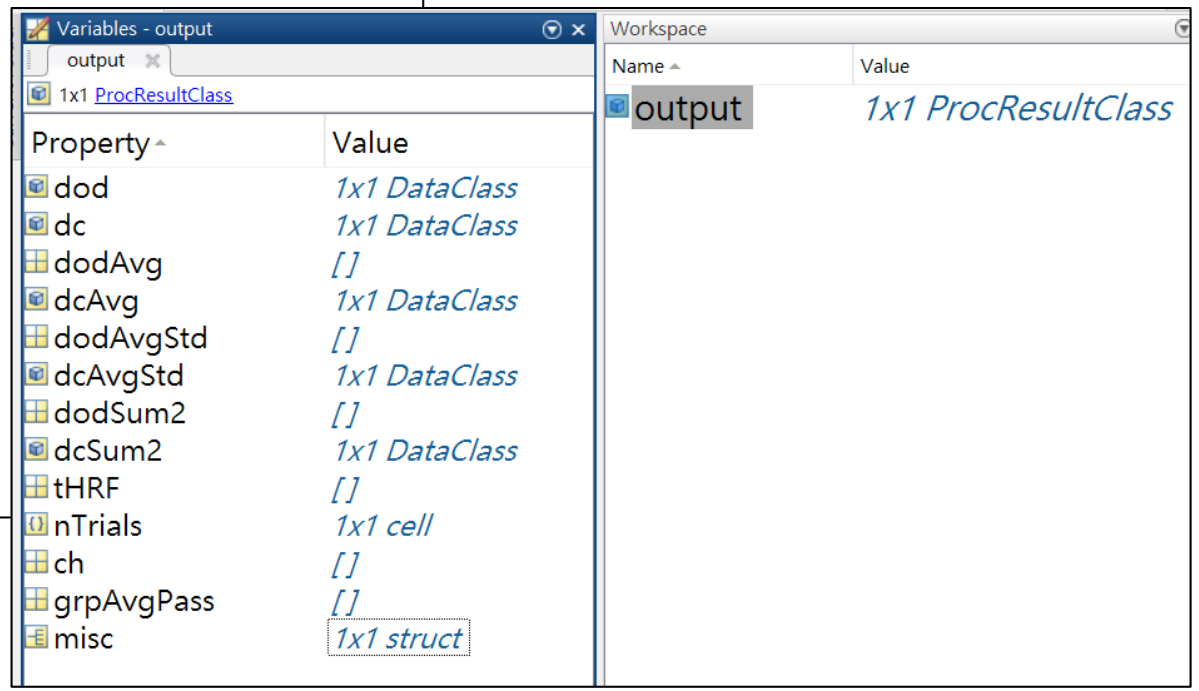
Processed Data from HOMER2/HOMER3

- MATLAB mat-file format (*.nirs)
  - load('Subj01.nirs','-mat')
- procInput:
  - Employed functions and parameters
- procResult:
  - Processed signals and parameters
- tIncMan:
  - Manually excluded time interval

Homer2 (*.nirs)



Homer3 (*.mat)



- MATLAB mat-file format
  - load('2021-03-04_003.mat')

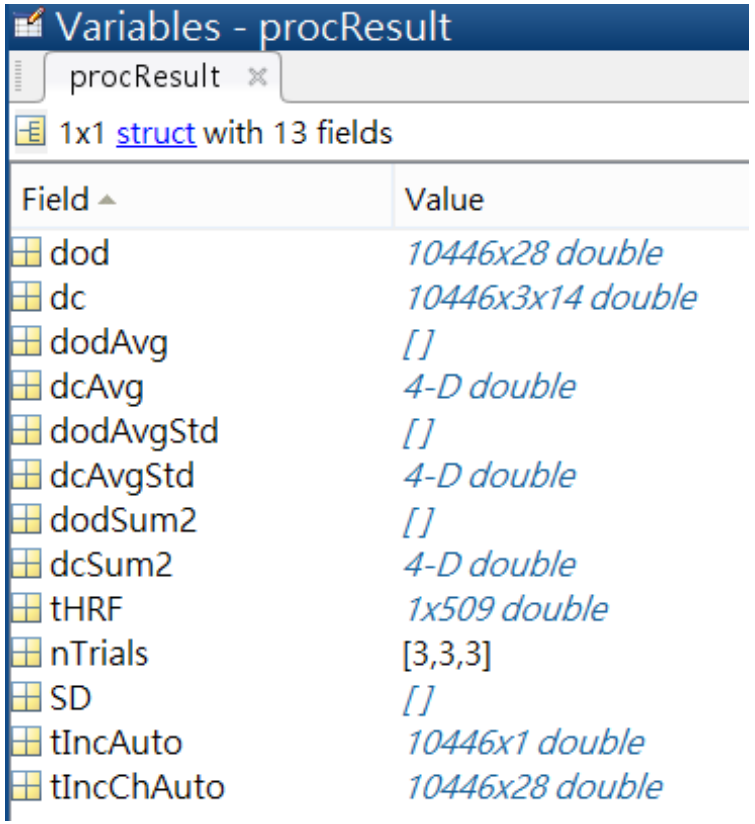
ProcResult (1/2)

dod: optical density signals
- data length x (channels x 2 wavelengths)

dc: Hb concentration signals
- data length x Hb components (HbO, HbR, Hbtotal) x channels

dcAvg: block averages of Hb signals
- Block length x Hb components x channels x conditions

dcAvgStd: STD of block averages
- Block length x Hb components x channels x conditions



ProcResult (2/2)

tHRF: time axis (in second) of block

- 1 x Block length

nTrials: number of each condition

- 1 x conditions

tIncAuto: excluded time interval

- Data length x 1

tIncChAuto: excluded time interval for each channel

- Data length x (channel x 2 wavelengths)

Variables - procResult

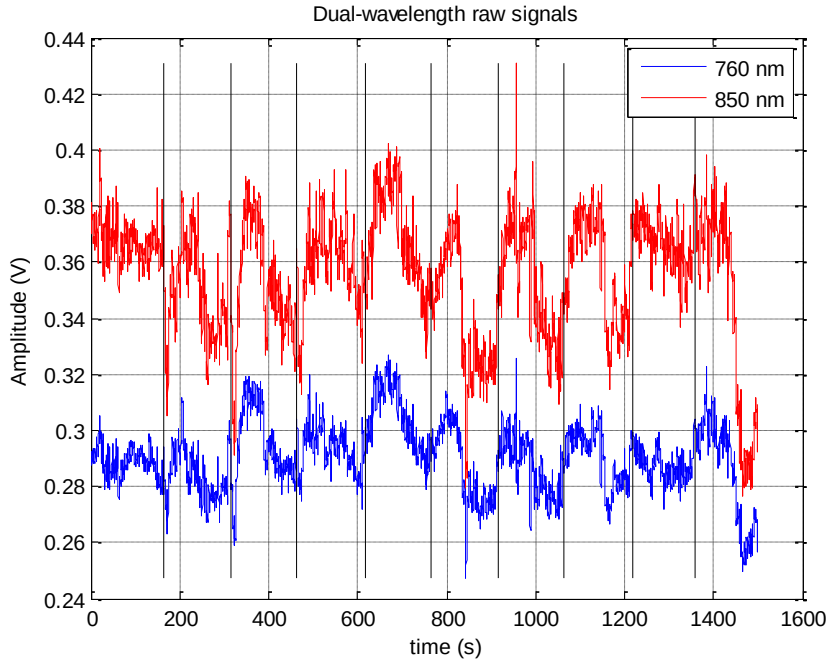
procResult

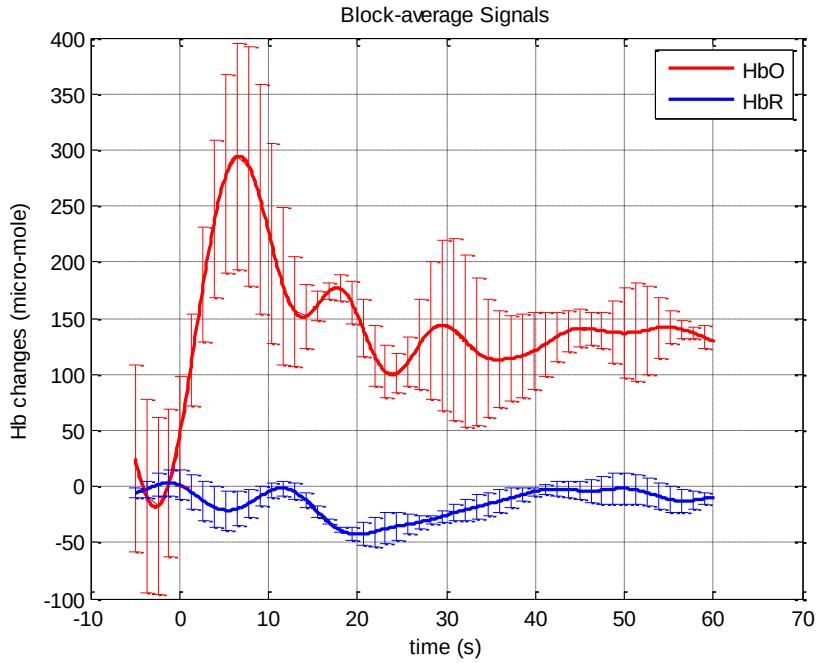
1x1 struct with 13 fields

Field	Value
dod	*10446x28 double*
dc	*10446x3x14 double*
dodAvg	*[ ]*
dcAvg	*4-D double*
dodAvgStd	*[ ]*
dcAvgStd	*4-D double*
dodSum2	*[ ]*
dcSum2	*4-D double*
tHRF	*1x509 double*
nTrials	[3,3,3]
SD	*[ ]*
tIncAuto	*10446x1 double*
tIncChAuto	*10446x28 double*

Plot Signals from *.nirs

Please run **PlotSigNIRS.m** and load a *.nirs file





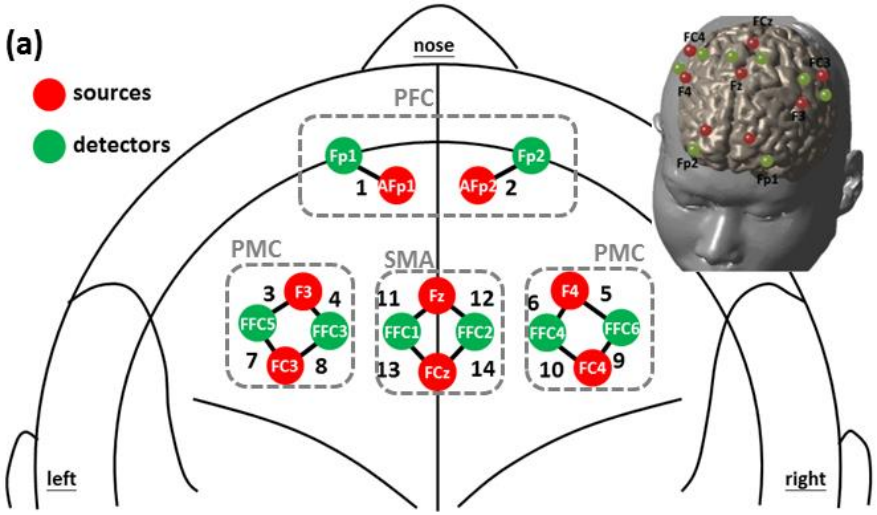
Example Dataset

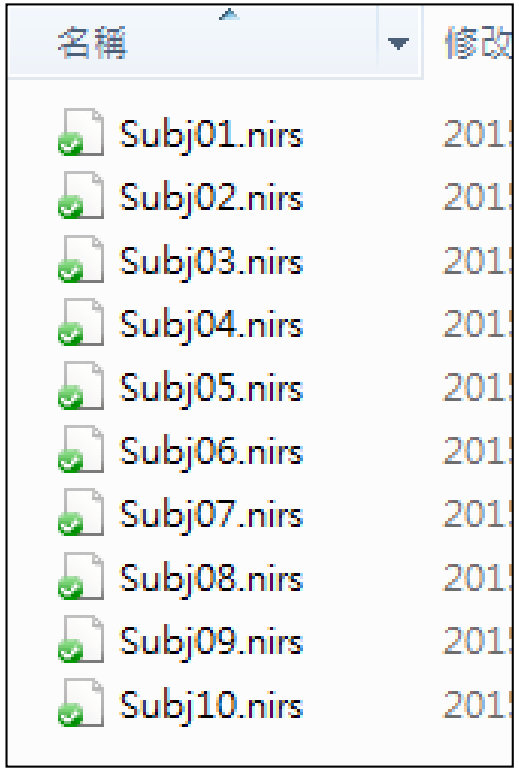
Lu et al. PloS one. 2015 Jun 16;10(6):e0129390.

10 subject processed files in the downloaded data folder

14 channels, 3 conditions (60 s)

1. Normal-pace walking (NW)
2. Walking while performing a cognitive task (WCT)
3. Walking while performing a motor task (WMT)





Intensity to OD

↓

Motion Artifacts By Channel
(0.5, 2.0, 20.0, 5.0)

↓

Spline Motion Correction
(0.99)

↓

Bandpass filter
(HPF = 0.01, LPF = 0.1)

↓

OD to Conc

↓

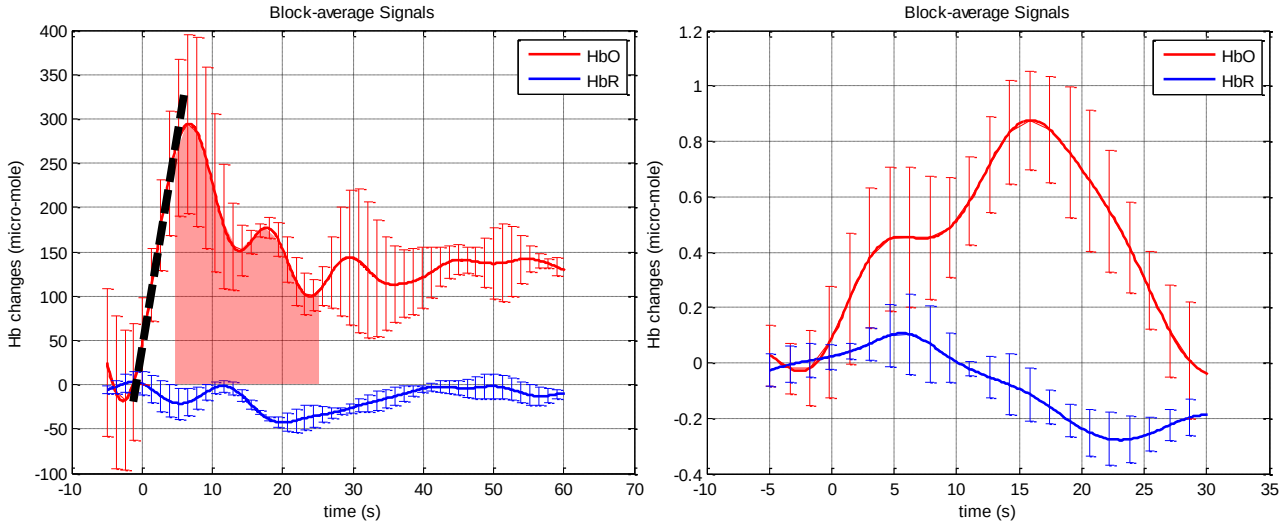
Block Average
(-5 60)

Quantitative Analysis

Signal mean (SM) during task block (within the period of 5~25 s)

Area under curve during task block (within the period of 5~25 s)

Signal slope (SS) within first 2~7 seconds during task block

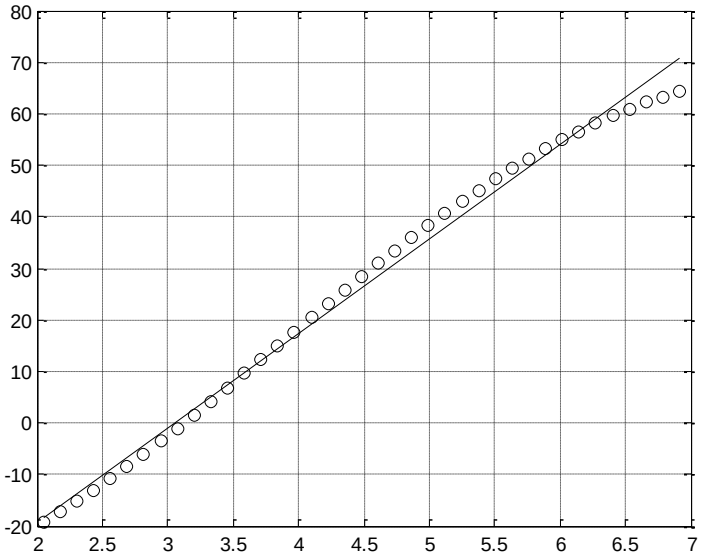


Quantitative Analysis

Please run **QuanAnalysis_excel.m**

- Load *.nirs files in the selected folder
- Plot mean signals for each channel and condition
- Calculate values of interest
  - SM, Area under curve, SS
- Output results into Excel files

Signal slope



Output to Excel files

Output data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		1	2	3	4	5	6	7	8	9	10	11	12	13	14
2	Subj #1	-2.21647	-0.39298	-8.45542	-8.89339	-6.10277	-11.295	-8.59166	-14.7985	-4.35418	-7.0636	-5.1188	-2.8265	-2.86812	-1.65084
3	Subj #2	14.63425	19.51131	11.85311	6.734553	14.4422	12.53427	11.61112	9.287581	13.28279	26.14657	9.355034	9.062778	15.84364	13.7941
4	Subj #3	6.880832	8.639391	-15.0624	17.29997	11.7926	9.971544	19.19651	27.41524	4.886163	6.419013	6.735763	3.951636	17.07166	23.60687
5	Subj #4	13.41732	2.299837	16.75914	12.3058	10.43942	4.847504	12.11043	15.7653	11.09249	17.44522	8.113566	7.290436	11.31536	10.56169
6	Subj #5	24.89119	10.82365	12.45225	17.05715	2.933162	15.3594	12.9121	26.45349	8.916727	14.54892	16.32959	11.90317	20.22203	15.16636
7	Subj #6	22.30749	24.70315	-3.193	2.03729	-10.4835	9.794145	-0.13395	0.641702	2.549545	-4.46562	-0.99295	-4.48382	-1.62093	-0.4104
8	Subj #7	35.53937	13.13692	9.915779	7.899169	13.95014	16.61813	3.006788	-2.90131	11.66749	16.17623	14.19464	12.79333	22.12574	17.29086
9	Subj #8	11.37175	13.25997	15.51856	14.00349	0.831987	8.441872	14.43075	17.59827	3.829416	8.449655	14.73077	11.69119	10.9844	8.321469
10	Subj #9	12.52891	6.058982	4.186033	2.055845	5.618188	-0.11519	4.964649	7.773187	-1.8205	-5.68195	9.057805	1.035922	1.168613	-1.03605
11	Subj #10	27.90544	15.59226	30.94456	30.60464	21.33821	19.7701	47.18935	49.73234	36.38593	59.20849	40.26558	32.38032	30.98159	32.44865

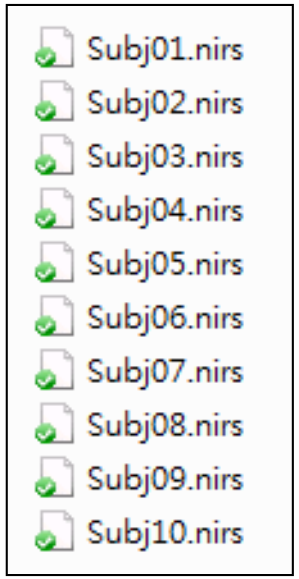
NW_Avg | WCT_Avg | WMT_Avg | NW_Area | WCT_Area | WMT_Area | NW_Slope | WCT_Slope | WMT_Slope

相關性分析

fNIRS Correlation Analysis

Correlation Analysis

Cerebral oxygenation vs. behavior !?



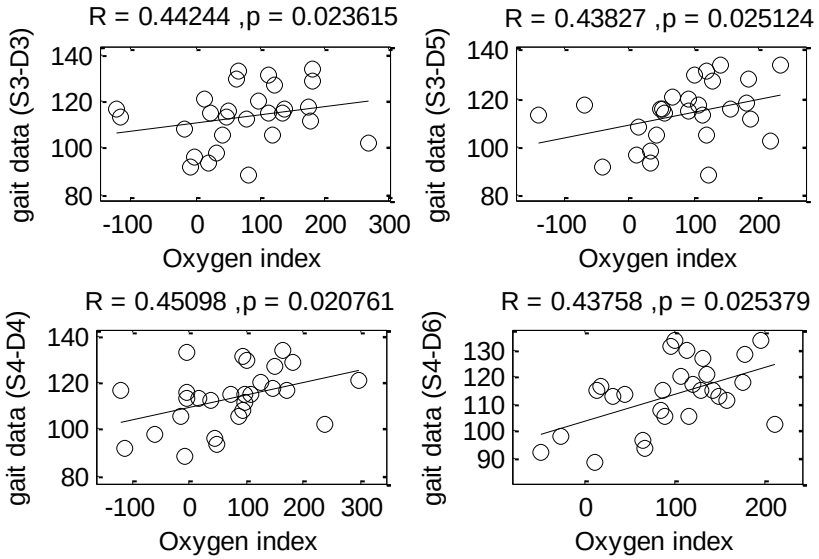
	A	B	C	D	E	F	G	H	I	J	K
1		speed(com)	cadence	stride time	stride length	speed(cog.)	cadence	stride time	stride length	speed(motor)	cadence
2	Subj01										
3	1	89.2	113.2	1.055	94.92	88.1	120.2	1	88.605	100.4	12
4	2	102.8	127.7	0.94	97.235	103.8	127.7	0.94	98.045	98.8	12
5	3	95.1	116.1	1.025	98.815	93.6	117.6	1.02	95.74	103.1	13
6	Subj02										
7	1	107.1	103.2	1.15	124.61	99.9	101.7	1.175	117.02	107.7	11
8	2	105.1	108.2	1.1	116.005	105.1	104.7	1.125	119.86	109.7	1
9	3	107.5	109.4	1.09	119.22	103.1	105.8	1.13	117.795		
10	Subj03										
11	1	115.1	111.8	1.065	125.025	90.7	101.5	1.17	107.73	114.7	11
12	2	109.4	106.8	1.12	122.745	98.1	105	1.14	112.805	107.2	1
13	3	110.1	109.7	1.08	122.035	104	109.1	1.09	115.12	113.5	11
14	Subj04										
15	1	108.6	112.3	1.055	116.02	113	108.2	1.1	113.485	103.4	11

Perform Correlation Analysis

Please run **HbCorrAnalysis.m**

load **data_gait** folder

Scatter plots



List

```
[Cond.3: motor] Significant Correlations with Speed :
  (Ch.3: S3-D3) R = 0.49472, P = 0.0074442.
  (Ch.4: S3-D5) R = 0.53995, P = 0.0030193.
  (Ch.7: S5-D3) R = 0.66982, P = 9.6699e-05.
  (Ch.8: S5-D5) R = 0.44878, P = 0.0166.
  (Ch.13: S8-D7) R = 0.50211, P = 0.0064758.
  (Ch.14: S8-D8) R = 0.41047, P = 0.030037.
[Cond.3: motor] Significant Correlations with Cadence :
[Cond.3: motor] Significant Correlations with StrideTime :
[Cond.3: motor] Significant Correlations with StrideLength :
  (Ch.3: S3-D3) R = 0.44914, P = 0.016504.
  (Ch.4: S3-D5) R = 0.51752, P = 0.0047961.
  (Ch.7: S5-D3) R = 0.73847, P = 7.2398e-06.
  (Ch.8: S5-D5) R = 0.39815, P = 0.03587.
  (Ch.9: S6-D4) R = 0.52222, P = 0.0043636.
  (Ch.13: S8-D7) R = 0.53457, P = 0.0033835.
  (Ch.14: S8-D8) R = 0.47762, P = 0.01016.
```

Notes

Use the partial correlation analysis to remove confounding effects (age, gender,…).

Use false discovery rate (FDR) to correct for the multiple correction.

Use the scatter plots to check the data distributions.

盧家鋒 Chia-Feng Lu, PhD

Q & A

Thanks for your attention :)