fNIRS結果呈現與相關性分析

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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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

資料繪製

HOMER Processed Data

Processed Data from HOMER2

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

Workspace

Name	Value
SD	*1x1 struct*
aux	*10446x1 double*
d	*10446x28 double*
ml	*28x4 double*
procInput	*1x1 struct*
procResult	*1x1 struct*
s	*10446x3 double*
t	*10446x1 double*
tIncMan	*10446x1 double*
userdata	*1x1 struct*

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

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*

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

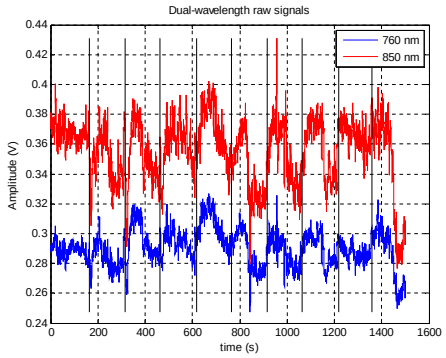
procResult

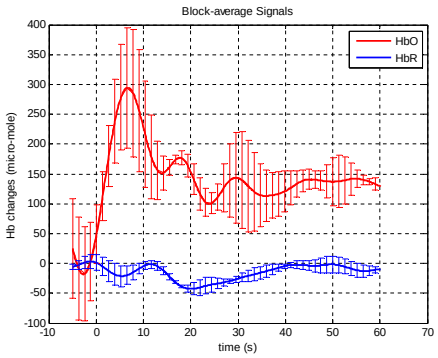
1x1 struct with 13 fields

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





定量分析

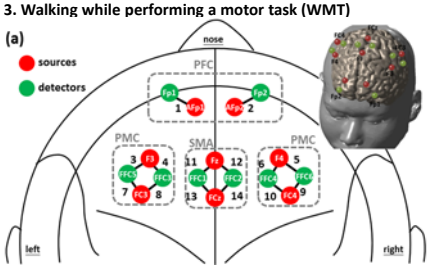
fNIRS Quantitative Analysis

Example Dataset

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)



名稱	修改日期	類型
Subj01.nirs	2015/5/28 上午 0...	NIRS 檔案
Subj02.nirs	2015/5/27 下午 1...	NIRS 檔案
Subj03.nirs	2015/5/27 下午 1...	NIRS 檔案
Subj04.nirs	2015/5/27 下午 1...	NIRS 檔案
Subj05.nirs	2015/5/27 下午 1...	NIRS 檔案
Subj06.nirs	2015/5/27 下午 1...	NIRS 檔案
Subj07.nirs	2015/5/27 下午 1...	NIRS 檔案
Subj08.nirs	2015/5/27 下午 1...	NIRS 檔案
Subj09.nirs	2015/5/27 下午 1...	NIRS 檔案
Subj10.nirs	2015/5/27 下午 1...	NIRS 檔案

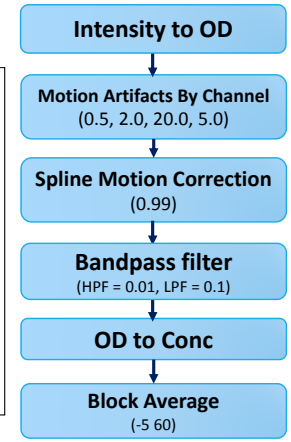
Processing flow

CV calculation

```
The rejection thresholds are:
  CVchannel > 15%
  CVtrial > 10%
The group averaged CVstandstill_w1 = 1.44%, CVstandstill_w2 = 1.93%

The channels have to be rejected based on criteria are listed as belows,
[Subject #1]: Subj01.nirs
  Channel #7 S5-D3, CVchannel_w1 = 38.78%, CVchannel_w2 = 35.13%
  Channel #8 S5-D5, CVchannel_w1 = 38.29%, CVchannel_w2 = 35.36%
[Subject #8]: Subj08.nirs
  Channel #5 S4-D4, CVchannel_w1 = 24.14%, CVchannel_w2 = 14.09%

The trials have to be rejected based on criteria are listed as belows,
[Subject #1]: Subj01.nirs
  Channel #8 S5-D5, Trial #4, CVtrial_w1 = 8.69%, CVtrial_w2 = 10.02%
[Subject #8]: Subj08.nirs
  Channel #5 S4-D4, Trial #2, CVtrial_w1 = 16.04%, CVtrial_w2 = 10.43%
  Channel #5 S4-D4, Trial #4, CVtrial_w1 = 39.86%, CVtrial_w2 = 18.58%
  Channel #5 S4-D4, Trial #8, CVtrial_w1 = 19.59%, CVtrial_w2 = 12.52%
  Channel #5 S4-D4, Trial #9, CVtrial_w1 = 39.73%, CVtrial_w2 = 12.74%
```

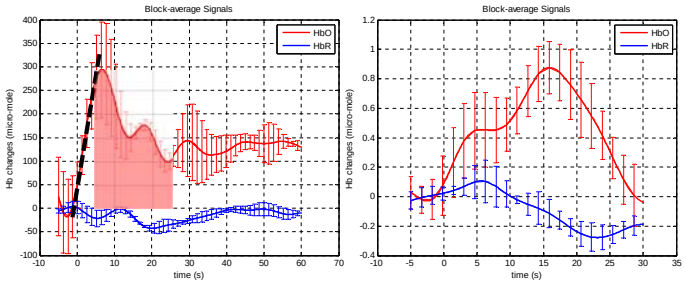


Quantitative Analysis

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)

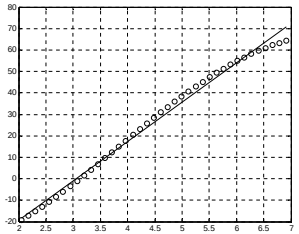
Signal slope (SS) within first 2~7 seconds during task block



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



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 !?

- Subj01.nirs
- Subj02.nirs
- Subj03.nirs
- Subj04.nirs
- Subj05.nirs
- Subj06.nirs
- Subj07.nirs
- Subj08.nirs
- Subj09.nirs
- Subj10.nirs

	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**

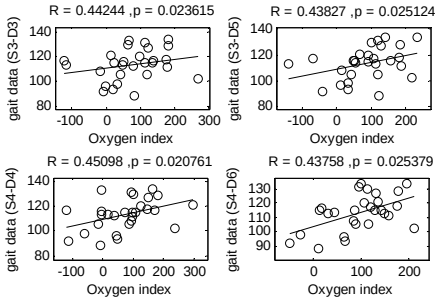
load data_gait folder

Correlation Results

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.
```

Scatter plots



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 :)