

# Investigation: does motion influence the correlation between PE and FA?

## Loading packages we'll need

```
% Adding packages we need
% For Plotting
addpath('C:\Users\dk00549\OneDrive - University of Surrey\Documents\Surrey\MATLAB\PluginsPrograms\Plotting');
% For emmeans
addpath('C:\Users\dk00549\OneDrive - University of Surrey\Documents\Surrey\MATLAB\PluginsPrograms\emmeans');
```

## Loading tables containing, PE, FA, and MO

PE = parameter estimates. In this case, these are parameter estimates for regions where white matter structure influences the tDCS-induced changes in brain activity.

FA = our metric for white matter structure. We are evaluating three tracts- whole skeleton (WS), the rAI-dACC/preSMA, or Salience Network tract (SN), and the mPFC-PCC/PRE, or Default Mode Network (DMN) tract.

MO = motion. Our metric are DVARS, though several others may be used as well.

```
PEandFA = readtable("PEandFA.xlsx");
MO = table2dataset(readtable("PTandHCMO.csv"));

% The below lines average the DVARS values per participant so they can be
% added to the PE and FA table. Two TBI participants had one fewer session
% than the others, and two healthy control participants had three more DVARS values
% than the others, so their means were calculated seperately.

df = [];
for k=1:width(MO)
    if k==5
        df(:,k) = mean(table2array(dataset2table(MO(1:784,k)))));
    elseif k==30
        df(:,k) = mean(table2array(dataset2table(MO(1:784,k)))));
    elseif k==43
        df(:,k) = mean(table2array(dataset2table(MO(1:1179,k)))));
    elseif k==51
        df(:,k) = mean(table2array(dataset2table(MO(1:1179,k)))));
    else
        df(:,k) = mean(table2array(dataset2table(MO(1:1176,k)))));
    end
end

df = array2table(df');
PEandFA(:,12) = df ;

T = table2dataset(PEandFA);

T.Properties.VarNames{1} = 'PE_Wholeskel_cope3';
T.Properties.VarNames{2} = 'PE_Wholeskel_cope5';
```

```

T.Properties.VarNames{3} = 'PE_Wholeskel_cope10';
T.Properties.VarNames{4} = 'PE_Wholeskel_cope11';
T.Properties.VarNames{5} = 'FA_WHOLESKEL';

T.Properties.VarNames{6} = 'PE_SN_cope3';
T.Properties.VarNames{7} = 'PE_SN_cope5';
T.Properties.VarNames{8} = 'FA_SN';

T.Properties.VarNames{9} = 'PE_DMN_cope3';
T.Properties.VarNames{10} = 'PE_DMN_cope10';
T.Properties.VarNames{11} = 'FA_DMN';

T.Properties.VarNames{12} = 'MO';
T.Properties.VarNames{13} = 'SubjID';

```

## Influence of motion on the relationship between WS FA and tDCS-induced changes in brain activity

```

% Four WS analysis:
%Columns 1:4 = WS PE
%Column 5 = WS FA

% Column 1
lme_light_clean1= fitglme(T,'PE_Wholeskel_cope3 ~ MO*FA_WHOLESKEL + (1|SubjID)');
disp(lme_light_clean1)

```

Generalized linear mixed-effects model fit by PL

### Model information:

Number of observations	55
Fixed effects coefficients	4
Random effects coefficients	55
Covariance parameters	2
Distribution	Normal
Link	Identity
FitMethod	MPL

### Formula:

```
PE_Wholeskel_cope3 ~ 1 + FA_WHOLESKEL*MO + (1 | SubjID)
```

### Model fit statistics:

AIC	BIC	LogLikelihood	Deviance
356.49	368.53	-172.24	344.49

### Fixed effects coefficients (95% CIs):

Name	Estimate	SE	tStat
{ '(Intercept)' }	-71.255	39.839	-1.7886
{ 'FA_WHOLESKEL' }	229.18	127.14	1.8026
{ 'MO' }	1.0303	5.8485	0.17617
{ 'FA_WHOLESKEL:MO' }	-3.6669	18.706	-0.19603

DF	pValue	Lower	Upper
51	0.079624	-151.24	8.7252
51	0.07736	-26.06	484.43
51	0.86086	-10.711	12.772
51	0.84536	-41.22	33.886

Random effects covariance parameters:

```

Group: SubjID (55 Levels)
  Name1      Name2      Type
  {'(Intercept)'} {'(Intercept)'} {'std'}

  Estimate
  3.9203

```

```

Group: Error
  Name      Estimate
  {'sqrt(Dispersion)'} 3.9203

```

```
anova(lme_light_clean1)
```

```

ans =
ANOVA marginal tests: DFMETHOD = 'residual'

  Term      FStat    DF1    DF2    pValue
  {'(Intercept)'}    3.199     1    51    0.079624
  {'FA_WHOLESKEL'}    3.2494    1    51    0.07736
  {'MO'}             0.031036    1    51    0.86086
  {'FA_WHOLESKEL:MO'} 0.038429    1    51    0.84536

```

```
% Interaction p val = 0.8
```

```
% Column 2
```

```

lme_light_clean1= fitglme(T, 'PE_Wholeskel_cope5 ~ MO*FA_WHOLESKEL + (1|SubjID)');
disp(lme_light_clean1)

```

Generalized linear mixed-effects model fit by PL

Model information:

```

Number of observations      55
Fixed effects coefficients    4
Random effects coefficients  55
Covariance parameters       2
Distribution                 Normal
Link                         Identity
FitMethod                    MPL

```

Formula:

```
PE_Wholeskel_cope5 ~ 1 + FA_WHOLESKEL*MO + (1 | SubjID)
```

Model fit statistics:

```

AIC      BIC      LogLikelihood    Deviance
395.53    407.57    -191.77    383.53

```

Fixed effects coefficients (95% CIs):

```

  Name      Estimate    SE    tStat
  {'(Intercept)'}    -61.556    56.815    -1.0834
  {'FA_WHOLESKEL'}    175.29    181.32     0.96677
  {'MO'}             -1.0709    8.3407    -0.12839
  {'FA_WHOLESKEL:MO'}    5.9746    26.676     0.22396

```

```

  DF    pValue    Lower    Upper
  51    0.28371    -175.62    52.505
  51    0.33822    -188.72    539.3
  51    0.89834    -17.815    15.674
  51    0.82368    -47.58     59.53

```

Random effects covariance parameters:

```

Group: SubjID (55 Levels)
  Name1      Name2      Type
  {'(Intercept)'} {'(Intercept)'} {'std'}

  Estimate
  5.5908

```

```

Group: Error
  Name      Estimate
  {'sqrt(Dispersion)'} 5.5908

```

```
anova(lme_light_clean1)
```

```

ans =
ANOVA marginal tests: DFMethod = 'residual'

  Term      FStat    DF1    DF2    pValue
  {'(Intercept)'}    1.1739     1    51    0.28371
  {'FA_WHOLESKEL'}    0.93464     1    51    0.33822
  {'MO'}              0.016485     1    51    0.89834
  {'FA_WHOLESKEL:MO'} 0.05016     1    51    0.82368

```

```
% Interaction p val = 0.8
```

```
% Column 3
```

```

lme_light_clean1= fitglme(T,'PE_Wholeskel_cope10 ~ MO*FA_WHOLESKEL + (1|SubjID)');
disp(lme_light_clean1)

```

Generalized linear mixed-effects model fit by PL

Model information:

```

Number of observations      55
Fixed effects coefficients    4
Random effects coefficients  55
Covariance parameters       2
Distribution                 Normal
Link                         Identity
FitMethod                    MPL

```

Formula:

```
PE_Wholeskel_cope10 ~ 1 + FA_WHOLESKEL*MO + (1 | SubjID)
```

Model fit statistics:

```

AIC      BIC      LogLikelihood    Deviance
417.26    429.31    -202.63      405.26

```

Fixed effects coefficients (95% CIs):

```

  Name      Estimate    SE    tStat
  {'(Intercept)'}    -46.637    69.225    -0.6737
  {'FA_WHOLESKEL'}     132.9    220.92     0.60159
  {'MO'}              -7.4665    10.163    -0.73471
  {'FA_WHOLESKEL:MO'}    25.7    32.503     0.7907

```

```

  DF    pValue    Lower    Upper
  51    0.50354    -185.61    92.339
  51    0.55011    -310.61    576.42
  51    0.46588    -27.869    12.936
  51    0.43278    -39.553    90.954

```

Random effects covariance parameters:

```

Group: SubjID (55 Levels)
  Name1      Name2      Type
  {'(Intercept)'} {'(Intercept)'} {'std'}

  Estimate
  6.8121

```

```

Group: Error
  Name      Estimate
  {'sqrt(Dispersion)'} 6.8121

```

```
anova(lme_light_clean1)
```

```

ans =
ANOVA marginal tests: DFMetho = 'residual'

  Term      FStat    DF1    DF2    pValue
  {'(Intercept)'}    0.45387    1    51    0.50354
  {'FA_WHOLESKEL'}    0.36191    1    51    0.55011
  {'MO'}              0.5398    1    51    0.46588
  {'FA_WHOLESKEL:MO'} 0.6252    1    51    0.43278

```

```
% Interaction p val = 0.4
```

```
% Column 4
```

```

lme_light_clean1= fitglme(T,'PE_Wholeskel_cope11 ~ MO*FA_WHOLESKEL + (1|SubjID)');
disp(lme_light_clean1)

```

Generalized linear mixed-effects model fit by PL

Model information:

```

Number of observations      55
Fixed effects coefficients    4
Random effects coefficients  55
Covariance parameters       2
Distribution                 Normal
Link                         Identity
FitMethod                    MPL

```

Formula:

```
PE_Wholeskel_cope11 ~ 1 + FA_WHOLESKEL*MO + (1 | SubjID)
```

Model fit statistics:

```

AIC      BIC      LogLikelihood    Deviance
424.07    436.12    -206.04    412.07

```

Fixed effects coefficients (95% CIs):

```

  Name      Estimate    SE    tStat
  {'(Intercept)'}    -170.92    73.646    -2.3208
  {'FA_WHOLESKEL'}     526.28    235.03     2.2392
  {'MO'}               13.954    10.812     1.2907
  {'FA_WHOLESKEL:MO'}  -41.931    34.579    -1.2126

```

```

  DF    pValue    Lower    Upper
  51    0.024334    -318.77    -23.066
  51    0.02953     54.443    998.13
  51    0.20263     -7.7508    35.659
  51    0.23087    -111.35     27.49

```

Random effects covariance parameters:

```

Group: SubjID (55 Levels)
  Name1      Name2      Type
  {'(Intercept)'} {'(Intercept)'} {'std'}

  Estimate
  7.2471

```

```

Group: Error
  Name      Estimate
  {'sqrt(Dispersion)'} 7.2471

```

```
anova(lme_light_clean1)
```

```

ans =
ANOVA marginal tests: DFMETHOD = 'residual'

  Term      FStat  DF1  DF2  pValue
  {'(Intercept)'}    5.3861    1    51  0.024334
  {'FA_WHOLESKEL'}    5.0141    1    51  0.02953
  {'MO'}              1.6659    1    51  0.20263
  {'FA_WHOLESKEL:MO'} 1.4704    1    51  0.23087

```

```
% Interaction p val = 0.2
```

## Influence of motion on the relationship between SN FA and tDCS-induced changes in brain activity

```

% Two SN analysis:
%Column 6:7 = SN PE
%Column 8 = SN FA

% Column 6
lme_light_clean1= fitglme(T,'PE_SN_cope3 ~ MO*FA_WHOLESKEL + (1|SubjID)');
disp(lme_light_clean1)

```

### Generalized linear mixed-effects model fit by PL

```

Model information:
  Number of observations      55
  Fixed effects coefficients    4
  Random effects coefficients  55
  Covariance parameters       2
  Distribution                 Normal
  Link                         Identity
  FitMethod                    MPL

```

```

Formula:
  PE_SN_cope3 ~ 1 + FA_WHOLESKEL*MO + (1 | SubjID)

```

```

Model fit statistics:
  AIC      BIC      LogLikelihood  Deviance
  381.01    393.06    -184.51      369.01

```

```

Fixed effects coefficients (95% CIs):
  Name      Estimate  SE      tStat
  {'(Intercept)'}    -21.865    49.79   -0.43915
  {'FA_WHOLESKEL'}     87.299   158.89    0.54941
  {'MO'}             -4.8009    7.3093   -0.65682
  {'FA_WHOLESKEL:MO'}  13.064   23.378    0.55883

```

DF	pValue	Lower	Upper
51	0.66241	-121.82	78.091
51	0.58512	-231.7	406.29
51	0.51425	-19.475	9.8731
51	0.57872	-33.869	59.997

#### Random effects covariance parameters:

Group: SubjID (55 Levels)

Name1	Name2	Type
{'(Intercept)'} }	{'(Intercept)'} }	{'std'}

Estimate  
4.8995

Group: Error

Name	Estimate
{'sqrt(Dispersion)'} }	4.8995

**anova(lme\_light\_clean1)**

ans =

ANOVA marginal tests: DFMethod = 'residual'

Term	FStat	DF1	DF2	pValue
{'(Intercept)'} }	0.19285	1	51	0.66241
{'FA_WHOLESKEL' }	0.30185	1	51	0.58512
{'MO' }	0.43142	1	51	0.51425
{'FA_WHOLESKEL:MO' }	0.31229	1	51	0.57872

% Interaction p val = 0.6

% Column 7

```
lme_light_clean1= fitglme(T,'PE_SN_cope5 ~ MO*FA_WHOLESKEL + (1|SubjID)');
disp(lme_light_clean1)
```

#### Generalized linear mixed-effects model fit by PL

##### Model information:

Number of observations	55
Fixed effects coefficients	4
Random effects coefficients	55
Covariance parameters	2
Distribution	Normal
Link	Identity
FitMethod	MPL

##### Formula:

PE\_SN\_cope5 ~ 1 + FA\_WHOLESKEL\*MO + (1 | SubjID)

##### Model fit statistics:

AIC	BIC	LogLikelihood	Deviance
389.97	402.01	-188.98	377.97

##### Fixed effects coefficients (95% CIs):

Name	Estimate	SE	tStat
{'(Intercept)'} }	46.842	54.014	0.86722
{'FA_WHOLESKEL' }	-151.04	172.38	-0.87626
{'MO' }	-10.23	7.9294	-1.2902
{'FA_WHOLESKEL:MO' }	32.065	25.361	1.2643

DF	pValue	Lower	Upper
51	0.38988	-61.595	155.28
51	0.385	-497.1	195.01
51	0.2028	-26.149	5.6885
51	0.21186	-18.85	82.979

#### Random effects covariance parameters:

Group: SubjID (55 Levels)

Name1	Name2	Type
{'(Intercept)'} }	{'(Intercept)'} }	{'std'}

Estimate  
5.3152

Group: Error

Name	Estimate
{'sqrt(Dispersion)'} }	5.3152

**anova(lme\_light\_clean1)**

ans =

ANOVA marginal tests: DFMethod = 'residual'

Term	FStat	DF1	DF2	pValue
{'(Intercept)'} }	0.75208	1	51	0.38988
{'FA_WHOLESKEL' }	0.76782	1	51	0.385
{'MO' }	1.6646	1	51	0.2028
{'FA_WHOLESKEL:MO' }	1.5985	1	51	0.21186

% Interaction p val = 0.2

### Influence of motion on the relationship between DMN FA and tDCS-induced changes in brain activity

% Two DMN analysis:

%Column 9:10 = DMN PE

%Column 11 = DMN FA

% Column 9

```
lme_light_clean1= fitglme(T,'PE_DMN_cope3 ~ MO*FA_WHOLESKEL + (1|SubjID)');
disp(lme_light_clean1)
```

#### Generalized linear mixed-effects model fit by PL

##### Model information:

Number of observations	55
Fixed effects coefficients	4
Random effects coefficients	55
Covariance parameters	2
Distribution	Normal
Link	Identity
FitMethod	MPL

##### Formula:

PE\_DMN\_cope3 ~ 1 + FA\_WHOLESKEL\*MO + (1 | SubjID)

##### Model fit statistics:

AIC	BIC	LogLikelihood	Deviance
-----	-----	---------------	----------



385.1      397.15      -186.55      373.1

#### Fixed effects coefficients (95% CIs):

Name	Estimate	SE	tStat
{'(Intercept)'} }	42.416	51.676	0.82081
{'FA_WHOLESKEL' }	-114.3	164.91	-0.69307
{'MO' }	-12.606	7.5862	-1.6617
{'FA_WHOLESKEL:MO'}	37.089	24.263	1.5286

DF	pValue	Lower	Upper
51	0.41557	-61.328	146.16
51	0.49141	-445.38	216.78
51	0.10271	-27.836	2.624
51	0.13255	-11.622	85.8

#### Random effects covariance parameters:

Group: SubjID (55 Levels)

Name1	Name2	Type
{'(Intercept)'} }	{'(Intercept)'} }	{'std'}

Estimate  
5.0851

Group: Error

Name	Estimate
{'sqrt(Dispersion)'} }	5.0851

**anova(lme\_light\_clean1)**

ans =

ANOVA marginal tests: DFMethod = 'residual'

Term	FStat	DF1	DF2	pValue
{'(Intercept)'} }	0.67373	1	51	0.41557
{'FA_WHOLESKEL' }	0.48034	1	51	0.49141
{'MO' }	2.7612	1	51	0.10271
{'FA_WHOLESKEL:MO'}	2.3366	1	51	0.13255

% Interaction p val = 0.1

% Column 10

```
lme_light_clean1= fitglme(T,'PE_DMN_cope10 ~ MO*FA_WHOLESKEL + (1|SubjID)');
disp(lme_light_clean1)
```

#### Generalized linear mixed-effects model fit by PL

##### Model information:

Number of observations	55
Fixed effects coefficients	4
Random effects coefficients	55
Covariance parameters	2
Distribution	Normal
Link	Identity
FitMethod	MPL

##### Formula:

PE\_DMN\_cope10 ~ 1 + FA\_WHOLESKEL\*MO + (1 | SubjID)

##### Model fit statistics:

AIC	BIC	LogLikelihood	Deviance
-----	-----	---------------	----------

387.35      399.39      -187.67      375.35

**Fixed effects coefficients (95% CIs):**

Name	Estimate	SE	tStat
{'(Intercept)'} }	18.506	52.742	0.35089
{'FA_WHOLESKEL' }	-62.451	168.32	-0.37103
{'MO' }	-8.4656	7.7427	-1.0934
{'FA_WHOLESKEL:MO'}	27.124	24.764	1.0953

DF	pValue	Lower	Upper
51	0.72712	-87.377	124.39
51	0.71215	-400.36	275.46
51	0.27937	-24.01	7.0786
51	0.27853	-22.592	76.84

**Random effects covariance parameters:**

Group: SubjID (55 Levels)

Name1	Name2	Type
{'(Intercept)'} }	{'(Intercept)'} }	{'std'}

Estimate  
5.19

Group: Error

Name	Estimate
{'sqrt(Dispersion)'} }	5.19

**anova(lme\_light\_clean1)**

ans =

**ANOVA marginal tests: DFMethod = 'residual'**

Term	FStat	DF1	DF2	pValue
{'(Intercept)'} }	0.12312	1	51	0.72712
{'FA_WHOLESKEL' }	0.13767	1	51	0.71215
{'MO' }	1.1954	1	51	0.27937
{'FA_WHOLESKEL:MO'}	1.1997	1	51	0.27853

**% Interaction p val = 0.3**