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\PluginsProgra
% For emmeans
addpath('C:\Users\dk00549\OneDrive - University of Surrey\Documents\Surrey\MATLAB\PluginsProgra
```

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 outliers. 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 ;
```

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

```
% Four WS analysis:
%Columns 1:4 = WS PE
```

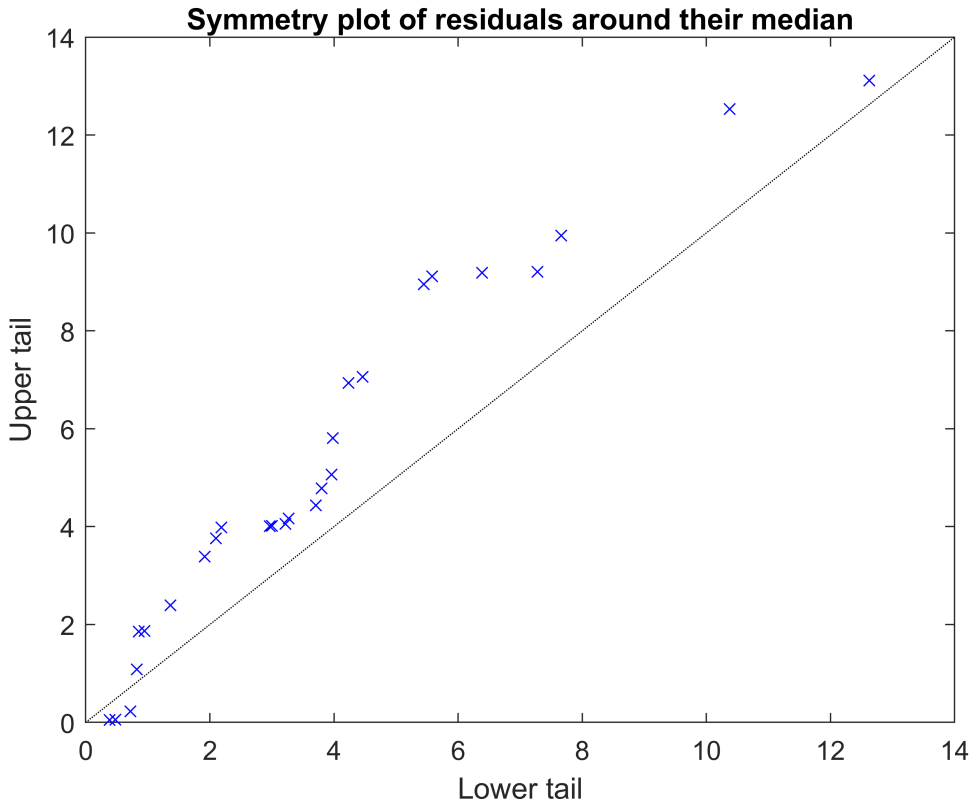
```
%Column 5 = WS FA

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';

% Column 1
lme_light_clean1= fitglme(T,'PE_Wholeskel_cope3 ~ MO*FA_WHOLESKEL');
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         0
    Covariance parameters               1
    Distribution                   Normal
    Link                           Identity
    FitMethod                      MPL

Formula:
    PE_Wholeskel_cope3 ~ 1 + FA_WHOLESKEL*MO

Model fit statistics:
    AIC       BIC       LogLikelihood    Deviance
    354.49    364.52    -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: Error
    Name                        Estimate
    {'sqrt(Dispersion)'}        5.5442
```

```
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
```

```
figure
plotResiduals(lme_light_clean1, 'symmetry')
```




```
% Interaction p val = 0.8

% Column 2
lme_light_clean1= fitglme(T,'PE_Wholeskel_cope5 ~ MO*FA_WHOLESKEL');
disp(lme_light_clean1)
```

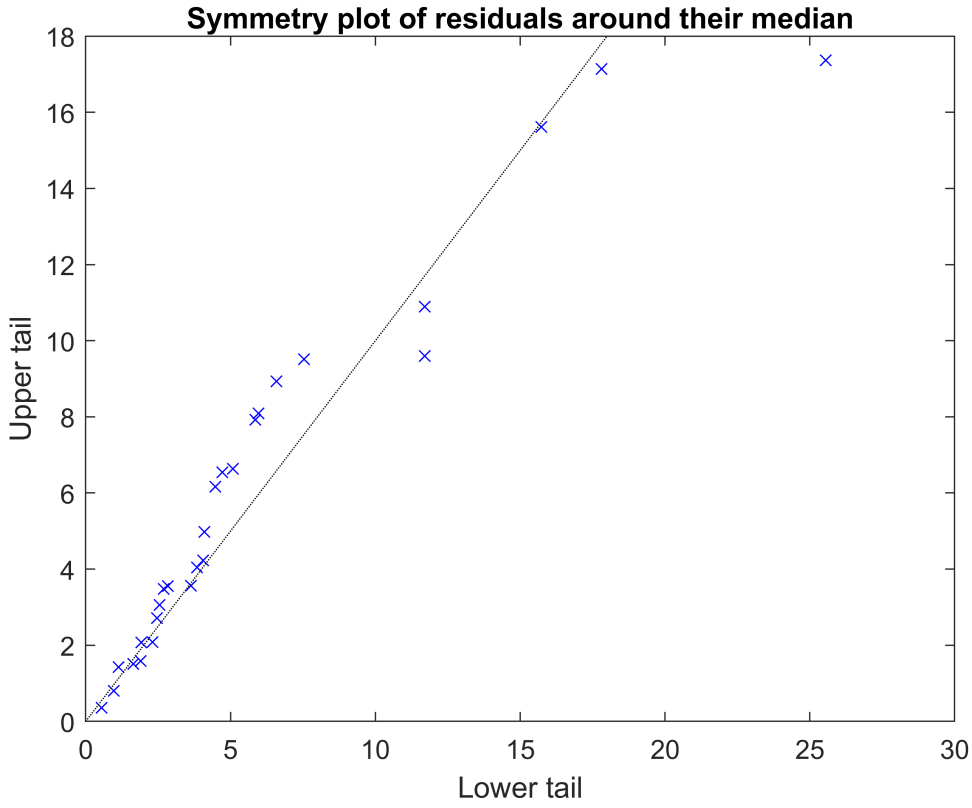
```
Generalized linear mixed-effects model fit by PL

Model information:
    Number of observations             55
    Fixed effects coefficients          4
    Random effects coefficients         0
    Covariance parameters               1
    Distribution                   Normal
    Link                           Identity
    FitMethod                      MPL

Formula:
```

```
    PE_Wholeskel_cope5 ~ 1 + FA_WHOLESKEL*MO

Model fit statistics:
    AIC       BIC       LogLikelihood    Deviance
    393.53    403.57    -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: Error
    Name                        Estimate
    {'sqrt(Dispersion)'}        7.9066
```

```
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
```

```
figure
plotResiduals(lme_light_clean1, 'symmetry')
```




```
% Interaction p val = 0.8

% Column 3
lme_light_clean1= fitglme(T,'PE_Wholeskel_cope10 ~ MO*FA_WHOLESKEL');
disp(lme_light_clean1)
```

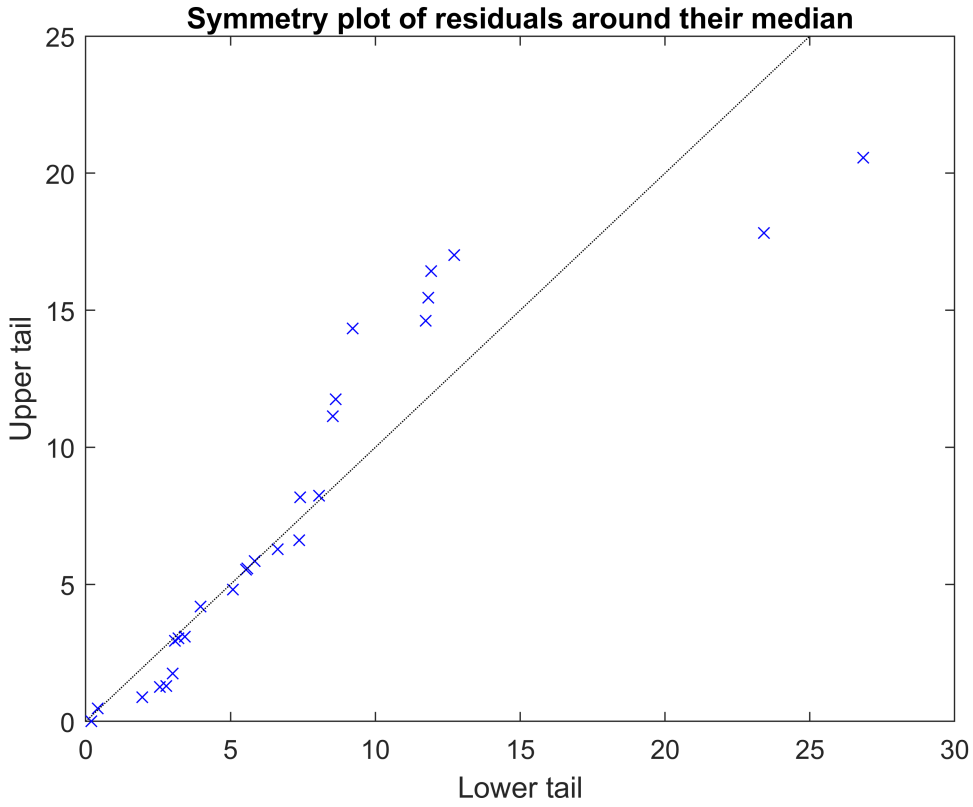
```
Generalized linear mixed-effects model fit by PL

Model information:
    Number of observations             55
    Fixed effects coefficients          4
    Random effects coefficients         0
    Covariance parameters               1
    Distribution                   Normal
    Link                           Identity
    FitMethod                      MPL

Formula:
    PE_Wholeskel_cope10 ~ 1 + FA_WHOLESKEL*MO

Model fit statistics:
    AIC       BIC      LogLikelihood    Deviance
    415.26    425.3    -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: Error
    Name                        Estimate
    {'sqrt(Dispersion)'}        9.6337
```

```
anova(lme_light_clean1)
```

```
ans =
    ANOVA marginal tests: DFMethod = '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
```

```
figure
plotResiduals(lme_light_clean1, 'symmetry')
```



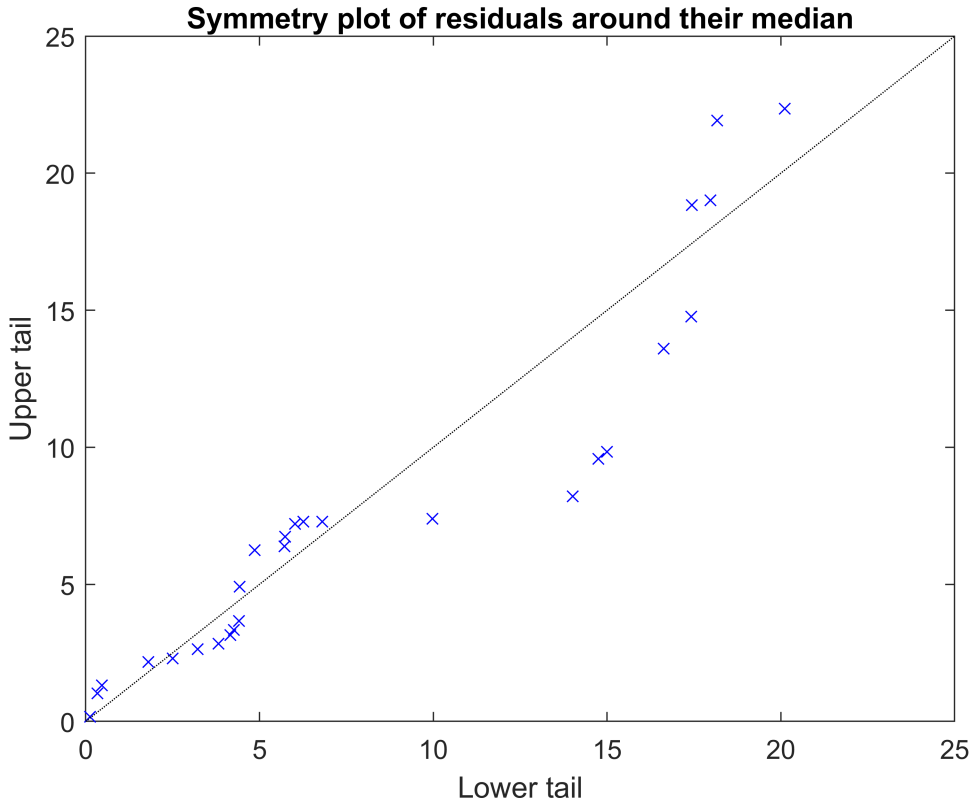

```
% Interaction p val = 0.4

% Column 4
lme_light_clean1= fitglme(T,'PE_Wholeskel_cope11 ~ MO*FA_WHOLESKEL');
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          0
    Covariance parameters                1
    Distribution                    Normal
    Link                            Identity
    FitMethod                       MPL

Formula:
    PE_Wholeskel_cope11 ~ 1 + FA_WHOLESKEL*MO

Model fit statistics:
    AIC       BIC       LogLikelihood    Deviance
    422.07    432.11    -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: Error
    Name                         Estimate
    {'sqrt(Dispersion)'}         10.249
```

```
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
```

```
figure
plotResiduals(lme_light_clean1, 'symmetry')
```




```
% 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');
disp(lme_light_clean1)
```

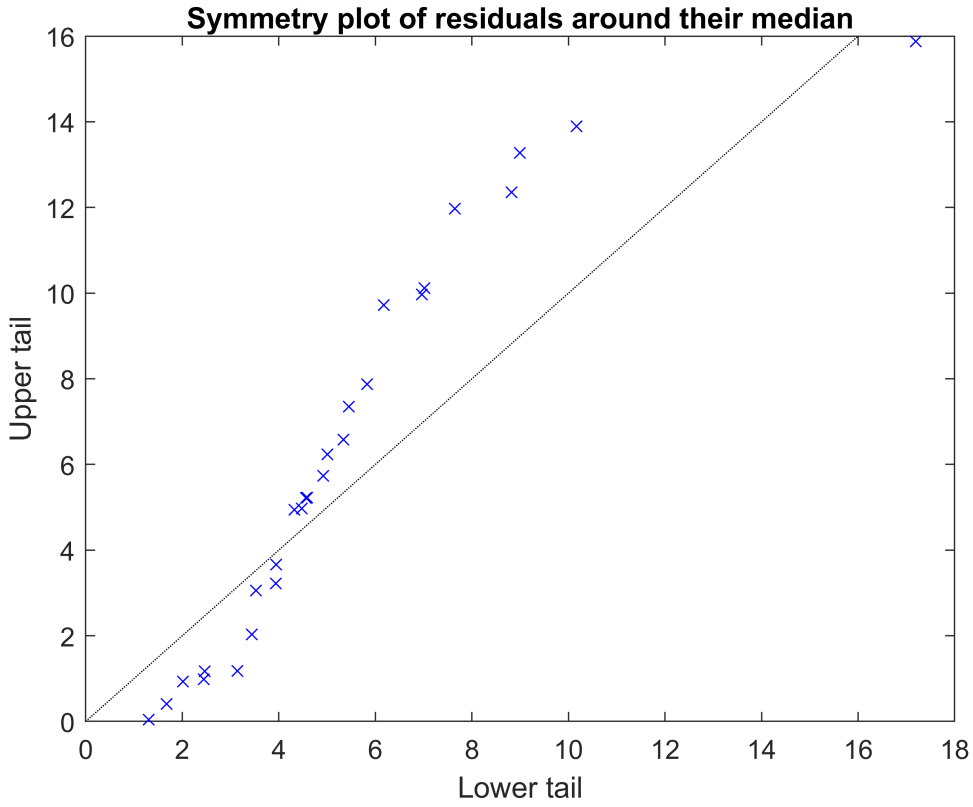
```
Generalized linear mixed-effects model fit by PL

Model information:
    Number of observations             55
    Fixed effects coefficients          4
    Random effects coefficients         0
    Covariance parameters               1
    Distribution                   Normal
    Link                           Identity
    FitMethod                      MPL

Formula:
    PE_SN_cope3 ~ 1 + FA_WHOLESKEL*MO

Model fit statistics:
    AIC       BIC       LogLikelihood    Deviance
    379.01    389.05    -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: Error
    Name                        Estimate
    {'sqrt(Dispersion)'}         6.9289
```

```
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
```

```
figure
plotResiduals(lme_light_clean1, 'symmetry')
```



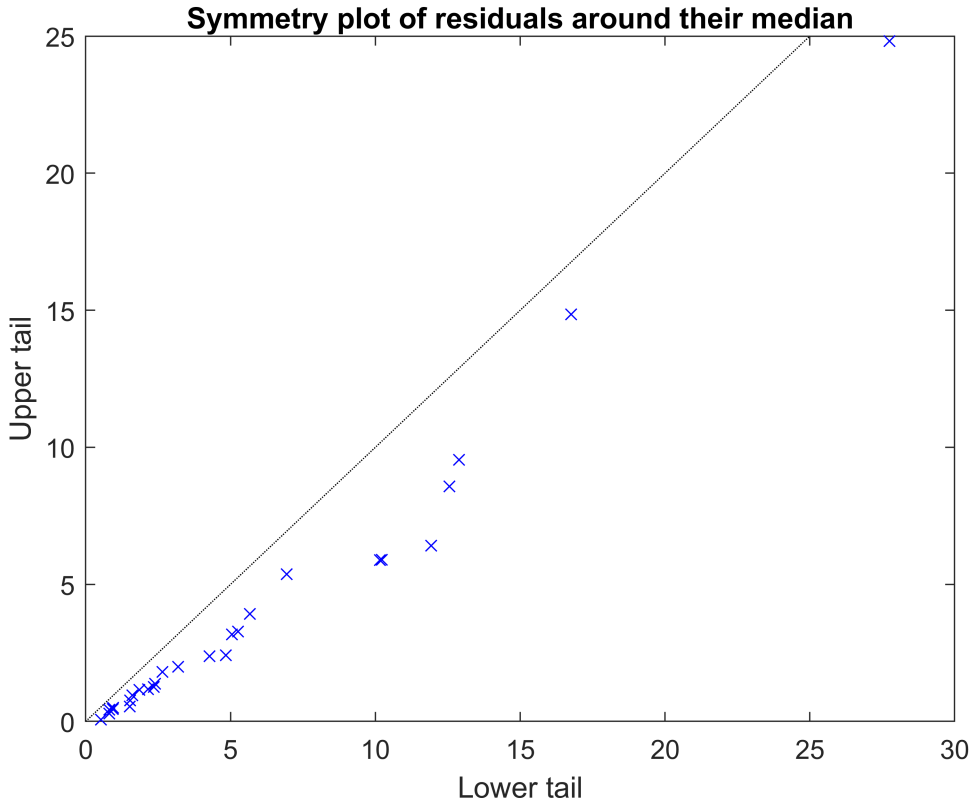
```
% Interaction p val = 0.6

% Column 7
lme_light_clean1= fitglme(T,'PE_SN_cope5 ~ MO*FA_WHOLESKEL');
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         0
    Covariance parameters               1
    Distribution                   Normal
    Link                           Identity
    FitMethod                      MPL

Formula:
    PE_SN_cope5 ~ 1 + FA_WHOLESKEL*MO

Model fit statistics:
    AIC       BIC       LogLikelihood    Deviance
    387.97    398.01    -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: Error
    Name                       Estimate
    {'sqrt(Dispersion)'}        7.5168
```

```
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
```

```
figure
plotResiduals(lme_light_clean1, 'symmetry')
```




```
% 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');
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         0
    Covariance parameters               1
    Distribution                   Normal
    Link                           Identity
    FitMethod                      MPL

Formula:
    PE_DMN_cope3 ~ 1 + FA_WHOLESKEL*MO

Model fit statistics:
    AIC      BIC       LogLikelihood    Deviance
    383.1    393.14    -186.55          373.1
```

Fixed effects coefficients (95% CIs):

Name	Estimate	SE	tStat	DF	pValue	Lower	Upper
{'(Intercept)' }	42.416	51.676	0.82081	51	0.41557	-61.328	146.16
{'FA_WHOLESKEL' }	-114.3	164.91	-0.69307	51	0.49141	-445.38	216.78
{'MO' }	-12.606	7.5862	-1.6617	51	0.10271	-27.836	2.624
{'FA_WHOLESKEL:MO'}	37.089	24.263	1.5286	51	0.13255	-11.622	85.8

Random effects covariance parameters:

Group: Error

Name	Estimate
{'sqrt(Dispersion)'}	7.1915

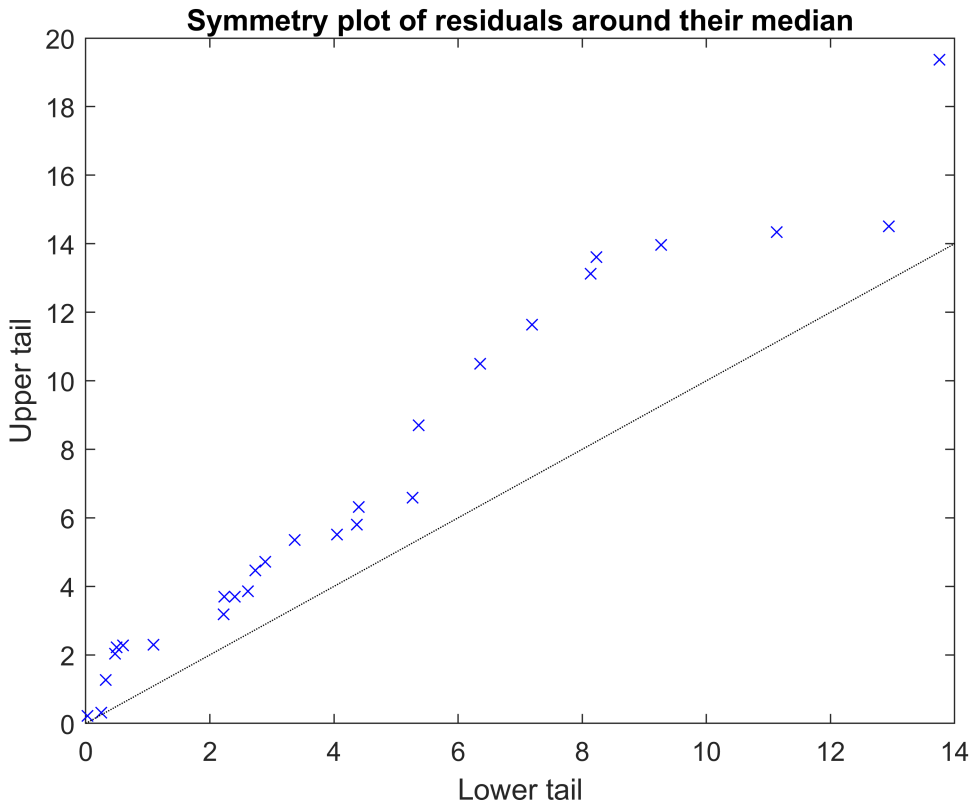
```
anova(lme_light_clean1)
```

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

```
figure
plotResiduals(lme_light_clean1, 'symmetry')
```




```
% Interaction p val = 0.1

% Column 10
lme_light_clean1= fitglme(T,'PE_DMN_cope10 ~ MO*FA_WHOLESKEL');
disp(lme_light_clean1)
```

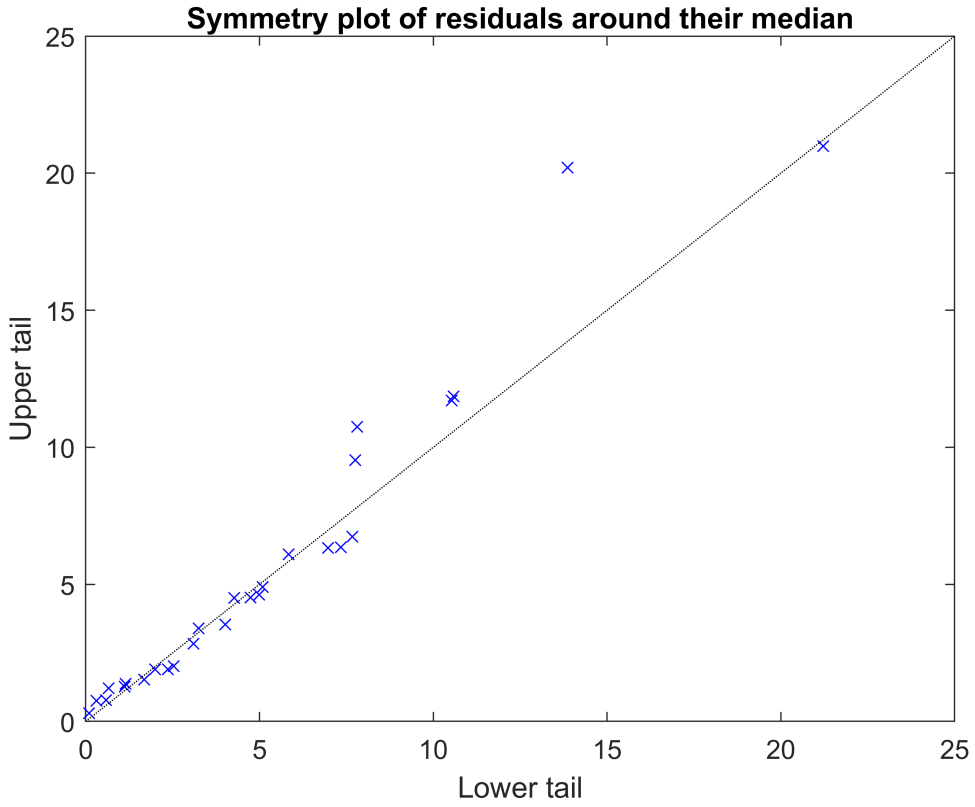
```
Generalized linear mixed-effects model fit by PL

Model information:
    Number of observations             55
    Fixed effects coefficients          4
    Random effects coefficients         0
    Covariance parameters               1
    Distribution                   Normal
    Link                           Identity
    FitMethod                      MPL

Formula:
    PE_DMN_cope10 ~ 1 + FA_WHOLESKEL*MO

Model fit statistics:
    AIC       BIC       LogLikelihood    Deviance
    385.35    395.38    -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: Error
    Name                        Estimate
    {'sqrt(Dispersion)'}        7.3398
```

```
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
```

```
figure
plotResiduals(lme_light_clean1, 'symmetry')
```




```
% Interaction p val = 0.3
```