Analysis

Neurophysiological Measures of Dual Tasking while Stepping in People with Parkinson's disease and Freezing of Gait

Conor **Fearon**[*1,2,3], John S. **Butler**[*1,4,5], Saskia M. **Waechter**[1,2], Isabelle **Killane**[1,2,7]

Simon P. **Kelly**[6], Richard B. **Reilly**[1,2,5] & Timothy **Lynch**[3]

[1]*Trinity Centre for Bioengineering, Trinity College, The University of Dublin, Dublin 2, Ireland*

[2]*School of Engineering, Trinity College, The University of Dublin, Dublin 2, Ireland*

[3] *Dublin Neurological Institute at the Mater Misericordiae University Hospital, Dublin 7, Ireland*

[4] *School of Mathematical Sciences, Dublin Institute of Technology, Kevin Street, Dublin, Ireland.*

[5]*School of Medicine, Trinity College, The University of Dublin, Dublin 2, Ireland*

[6]*School of Electrical & Electronic Engineering, University College Dublin, Dublin 4, Ireland*

[7] *School of Mechanical and Design Engineering, Dublin Institute of Technology, Bolton Street, Dublin, Ireland.*

Analysis

R Version Information

```
version
```

```
##                _
## platform       x86_64-w64-mingw32
## arch           x86_64
## os             mingw32
## system         x86_64, mingw32
## status
## major          3
## minor          5.1
## year           2018
## month          07
## day            02
## svn rev        74947
## language       R
## version.string R version 3.5.1 (2018-07-02)
## nickname       Feather Spray
```

Data Read in

Read in and summary of response time data

```
library(BayesFactor)
```

```
## Loading required package: coda
```

```
## Loading required package: Matrix
```

```
## ************
## Welcome to BayesFactor 0.9.12-4.2. If you have questions, please contact R
ichard Morey (richarddmorey@gmail.com).
##
## Type BFManual() to open the manual.
## ************
```

```
DATA<-read.csv("CSVDATA/DATA_3groups.csv")
summary(DATA)
```

```
##   Observation    FOGStatus Condition       RT           Subject
##  Min.   : 1.00   C   :14   SIT :25   Min.   :379.9   Min.   : 1
##  1st Qu.:13.25   FOG-:20   STEP:25   1st Qu.:482.3   1st Qu.: 7
##  Median :25.50   FOG+:16             Median :531.2   Median :13
##  Mean   :25.50                       Mean   :541.6   Mean   :13
##  3rd Qu.:37.75                       3rd Qu.:575.4   3rd Qu.:19
##  Max.   :50.00                       Max.   :873.0   Max.   :25
##       LRP                 N2                CPP
##  Min.   :-63.3396   Min.   :-21.3601   Min.   :-4.026
##  1st Qu.:-29.7995   1st Qu.:  0.6236   1st Qu.:13.659
##  Median : -8.7243   Median :  6.2337   Median :25.441
```

```
##  Mean   :-14.6815   Mean   :  7.7804   Mean   :27.537
##  3rd Qu.:  0.9285   3rd Qu.: 14.1697   3rd Qu.:33.135
##  Max.   : 32.5867   Max.   : 45.1200   Max.   :74.604

DATA$ID<-factor(DATA$Subject)
```

Behavioural Data

ANOVA

```
aovRT<-aov(RT~Condition*FOGStatus+Error(factor(Subject)/Condition),DATA)
summary(aovRT)

##
## Error: factor(Subject)
##           Df Sum Sq Mean Sq F value   Pr(>F)
## FOGStatus  2 182752   91376   9.675 0.000967 ***
## Residuals 22 207775    9444
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: factor(Subject):Condition
##                      Df Sum Sq Mean Sq F value   Pr(>F)
## Condition             1   2386    2386   1.786 0.195132
## Condition:FOGStatus   2  33361   16681  12.480 0.000239 ***
## Residuals            22  29405    1337
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

bfRT = anovaBF(RT ~ Condition*FOGStatus + ID, data = DATA, whichRandom="ID")
(bfRT)

## Bayes factor analysis
## --------------
## [1] FOGStatus + ID                                    : 33.84484  ±1.65%
## [2] Condition + ID                                    : 0.6276213 ±32.27%
## [3] FOGStatus + Condition + ID                        : 15.33684  ±7.66%
## [4] FOGStatus + Condition + FOGStatus:Condition + ID : 1105.58   ±2.64%
##
## Against denominator:
##   RT ~ ID
## ---
## Bayes factor type: BFlinearModel, JZS
```

Table of Reaction times

```
library(knitr)
meanRT<-with(DATA, tapply(RT, list(FOGStatus, Condition), FUN= mean))
meanSD<-with(DATA, tapply(RT, list(FOGStatus, Condition), FUN= sd))
kable(meanRT,caption="Mean Reaction Time")
```

Analysis

Mean Reaction Time

	SIT	STEP
C	470.9765	448.2508
FOG-	549.9789	529.1361
FOG+	571.4405	660.5581

```
kable(meanSD,caption="Standard Deviation of Reaction Time")
```

Standard Deviation of Reaction Time

	SIT	STEP
C	52.29475	52.66179
FOG-	81.83508	64.57883
FOG+	55.38286	110.09988

Follow up t-test and Bayes analysis

```
temp<-with(DATA,
       by(DATA, FOGStatus,
          function(x) t.test(RT ~ Condition, data=x,paired=TRUE)
       )
     )
temp
```

```
## FOGStatus: C
##
##  Paired t-test
##
## data:  RT by Condition
## t = 4.03, df = 6, p-value = 0.006881
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##   8.927104 36.524400
## sample estimates:
## mean of the differences
##                22.72575
##
## ------------------------------------------------------------
## FOGStatus: FOG-
##
##  Paired t-test
##
## data:  RT by Condition
## t = 1.968, df = 9, p-value = 0.0806
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -3.11523 44.80073
## sample estimates:
## mean of the differences
```

```
##                20.84275
##
## ------------------------------------------------------
## FOGStatus: FOG+
##
##  Paired t-test
##
## data:  RT by Condition
## t = -3.0638, df = 7, p-value = 0.01823
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -157.89767  -20.33757
## sample estimates:
## mean of the differences
##               -89.11762
```

```
exp(ttest.tstat(t=temp$C$statistic, n1=temp$C$parameter, rscale = 0.707)[['bf
']])
```

```
## [1] 6.888605
```

```
exp(ttest.tstat(t=temp$`FOG-`$statistic, n1=temp$`FOG-`$parameter, rscale = 0
.707)[['bf']])
```

```
## [1] 1.236865
```

```
exp(ttest.tstat(t=temp$`FOG+`$statistic, n1=temp$`FOG+`$parameter, rscale = 0
.707)[['bf']])
```

```
## [1] 3.65676
```

EEG Analysis

CPP/P3 Analysis

ANOVA

```
aovCPP<-aov(CPP~Condition*FOGStatus+Error(factor(Subject)/Condition),DATA)
summary(aovCPP)
```

```
##
## Error: factor(Subject)
##           Df Sum Sq Mean Sq F value Pr(>F)
## FOGStatus  2    787   393.6   0.807  0.459
## Residuals 22  10727   487.6
##
## Error: factor(Subject):Condition
##                      Df Sum Sq Mean Sq F value Pr(>F)
## Condition             1      6     5.6   0.030  0.865
## Condition:FOGStatus   2    869   434.4   2.311  0.123
## Residuals            22   4135   188.0
```

```
bfCPP = anovaBF(CPP ~ Condition*FOGStatus + ID, data = DATA, whichRandom="ID"
)
(bfCPP)

## Bayes factor analysis
## --------------
## [1] FOGStatus + ID                                    : 0.4143429 ±0.54%
## [2] Condition + ID                                    : 0.2802281 ±1.36%
## [3] FOGStatus + Condition + ID                        : 0.1159533 ±1.12%
## [4] FOGStatus + Condition + FOGStatus:Condition + ID : 0.119338  ±1.88%
##
## Against denominator:
##   CPP ~ ID
## ---
## Bayes factor type: BFlinearModel, JZS
```

Table of P3/CPP amplitude

```
meanCPP<-with(DATA, tapply(CPP, list(FOGStatus, Condition), FUN= mean))
sdCPP<-with(DATA, tapply(CPP, list(FOGStatus, Condition), FUN= sd))
kable(meanCPP,caption="Mean P3/CPP amplitude")
```

Mean P3/CPP amplitude

	SIT	STEP
C	39.28740	26.12272
FOG-	27.43303	28.50150
FOG+	18.43009	26.52459

```
kable(sdCPP,caption="Standard Deviation of P3/CPP Amplitude")
```

Standard Deviation of P3/CPP Amplitude

	SIT	STEP
C	22.38829	18.77136
FOG-	20.48657	14.40415
FOG+	16.68518	17.51630

N2 Analysis

ANOVA

```
aovN2<-aov(N2~Condition*FOGStatus+Error(factor(Subject)/Condition),DATA)
summary(aovN2)

##
## Error: factor(Subject)
##           Df Sum Sq Mean Sq F value Pr(>F)
## FOGStatus  2   1373   686.3   3.638 0.0431 *
## Residuals 22   4150   188.6
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: factor(Subject):Condition
##                     Df Sum Sq Mean Sq F value Pr(>F)
## Condition            1  389.5   389.5   4.251 0.0512 .
## Condition:FOGStatus  2  375.6   187.8   2.049 0.1527
## Residuals           22 2015.8    91.6
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
bfN2 = anovaBF(N2 ~ Condition*FOGStatus + ID, data = DATA, whichRandom="ID")
(bfN2)
```

```
## Bayes factor analysis
## --------------
## [1] FOGStatus + ID                                    : 1.591669 ±0.71%
## [2] Condition + ID                                    : 1.40693  ±3.05%
## [3] FOGStatus + Condition + ID                        : 2.285585 ±1.03%
## [4] FOGStatus + Condition + FOGStatus:Condition + ID : 2.212719 ±7.15%
##
## Against denominator:
##   N2 ~ ID
## ---
## Bayes factor type: BFlinearModel, JZS
```

Table of N2 amplitude

```
meanN2<-with(DATA, tapply(N2, list(FOGStatus, Condition), FUN= mean))
sdN2<-with(DATA, tapply(N2, list(FOGStatus, Condition), FUN= sd))
kable(meanN2,caption="Mean N2 amplitude")
```

Mean N2 amplitude

	SIT	STEP
C	15.762859	16.575715
FOG-	3.534110	6.118185
FOG+	-2.618896	10.884703

```
kable(sdN2,caption="Standard Deviation of N2 Amplitude")
```

Standard Deviation of N2 Amplitude

	SIT	STEP
C	9.412881	13.607847
FOG-	16.741922	10.095372
FOG+	8.882891	8.708435

Follow up t-test and Bayes analysis on N2 amplitude

```
temp<-with(DATA,
       by(DATA, FOGStatus,
```

```
          function(x) t.test(N2 ~ Condition, data=x,paired=TRUE)
       )
     )
temp
```

```
## FOGStatus: C
##
##  Paired t-test
##
## data:  N2 by Condition
## t = -0.19706, df = 6, p-value = 0.8503
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -10.906165   9.280453
## sample estimates:
## mean of the differences
##              -0.8128562
##
## ------------------------------------------------------------
## FOGStatus: FOG-
##
##  Paired t-test
##
## data:  N2 by Condition
## t = -0.4887, df = 9, p-value = 0.6367
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -14.545541   9.377391
## sample estimates:
## mean of the differences
##               -2.584075
##
## ------------------------------------------------------------
## FOGStatus: FOG+
##
##  Paired t-test
##
## data:  N2 by Condition
## t = -3.5712, df = 7, p-value = 0.009082
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -22.444710  -4.562487
## sample estimates:
## mean of the differences
##                -13.5036
```

```
exp(ttest.tstat(t=temp$C$statistic, n1=temp$C$parameter, rscale = 0.707)[['bf
']])
```

```
## [1] 0.3793454
```

```
exp(ttest.tstat(t=temp$`FOG-`$statistic, n1=temp$`FOG-`$parameter, rscale = 0
.707)[['bf']])
```

```
## [1] 0.3557901
```

```
exp(ttest.tstat(t=temp$`FOG+`$statistic, n1=temp$`FOG+`$parameter, rscale = 0
.707)[['bf']])
```

```
## [1] 5.923786
```

LRP Analysis

ANOVA

```
aovLRP<-aov(LRP~Condition*FOGStatus+Error(factor(Subject)/Condition),DATA)
summary(aovLRP)
```

```
##
## Error: factor(Subject)
##           Df Sum Sq Mean Sq F value  Pr(>F)
## FOGStatus  2   8275    4137   7.889 0.00261 **
## Residuals 22  11538     524
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: factor(Subject):Condition
##                     Df Sum Sq Mean Sq F value Pr(>F)
## Condition            1  119.8   119.8   0.941  0.343
## Condition:FOGStatus  2  506.2   253.1   1.987  0.161
## Residuals           22 2801.9   127.4
```

```
bfLRP = anovaBF(LRP ~ Condition*FOGStatus + ID, data = DATA, whichRandom="ID"
)
(bfLRP)
```

```
## Bayes factor analysis
## --------------
## [1] FOGStatus + ID                                    : 17.22485  ±2.78%
## [2] Condition + ID                                    : 0.3858644 ±0.92%
## [3] FOGStatus + Condition + ID                        : 6.642125  ±2.85%
## [4] FOGStatus + Condition + FOGStatus:Condition + ID : 5.128311  ±2.83%
##
## Against denominator:
##   LRP ~ ID
## ---
## Bayes factor type: BFlinearModel, JZS
```

Table of LRP Data

```
meanLRP<-with(DATA, tapply(LRP, list(FOGStatus, Condition), FUN= mean))
sdLRP<-with(DATA, tapply(LRP, list(FOGStatus, Condition), FUN= sd))
kable(meanLRP,caption="Mean LRP amplitude")
```

Analysis

Mean LRP amplitude

	SIT	STEP
C	-6.267251	-3.179214
FOG-	-11.581859	-1.774834
FOG+	-30.755896	-36.041696

```
kable(sdLRP,caption="Standard Deviation of LRP Amplitude")
```

Standard Deviation of LRP Amplitude

	SIT	STEP
C	4.025116	10.61482
FOG-	15.740234	24.49883
FOG+	21.384566	19.76201