Task 1 - SMLP 2022: Analysis MS 2

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Cardiac synchrony and its role in language development

This is part of my PhD project which examines the role of mother-infant interpersonal synchrony on language development. Specifically, in this script, I test the following RQ. Does mother-infant cardiac synchrony predict infants' word segmentation ability? We include data of 29 dyads who performed two different tasks:

- **word-segmentation task**: infants underwent an eye-tracking task. During the familiarization phase they were listening to a story containing target words (i.e., familiar words). Then, they were tested with familiar (6 trials) and novel (6 trials) words. We measured their looking time (LT) in msec while listening to novel vs. familiar words. LT was our dependent variable.
- **5-minutes free play interaction**: mothers were asked to play with the baby as they would do at home. During this time we recorded dual ECG. We then followed the following processing steps:

1. we extracted offline Interbeat-intervals (IBIs)
2. we calculated Respiratory Sinus Arrhythmia (RSA)
3. to collect a more continuous measure of RSA, a sliding window of 15 s was used to extract a continuous estimate of cardiac vagal tone for both participants
4. to identify coupling/synchrony between mothers' and infants' RSA time-series we used cross-recurrence quantification analysis (CRQA)
5. CRQA gave us a bunch of metrics: RR, det, NRLINE, maxline, entropy, lam, TT
6. we ran principal component analysis and we decide to include the first two components (pc1 and pc2), which had eigenvalues higher than 1 (Kaiser Rule).

Part 1: data preparation

```
library(readxl)
```

```
## Warning: package 'readxl' was built under R version 4.0.5
```

```
lang_ECG <- read.csv("D:/PhD project/Conferences-SummerSchools/SMLP 2022/lang_ECG.csv", header=TRUE, se
str(lang_ECG)
```

```
## 'data.frame':    426 obs. of  7 variables:
##  $ Participant: int  10 10 10 10 10 10 10 10 10 10 ...
##  $ Phase      : chr  "familiarization" "familiarization" "familiarization" "familiarization" ...
##  $ Familiarity: chr  "famphase" "famphase" "famphase" "famphase" ...
##  $ LT         : num  1.17 2.65 15.26 11.68 5.49 ...
##  $ PC1        : num  -0.572 -0.572 -0.572 -0.572 -0.572 ...
##  $ PC2        : num  -0.092 -0.092 -0.092 -0.092 -0.092 ...
##  $ PC3        : num  -2.25 -2.25 -2.25 -2.25 -2.25 ...
```

```
lang_ECG$Participant <- as.factor(lang_ECG$Participant)
lang_ECG$Phase <- as.factor(lang_ECG$Phase)
lang_ECG$Familiarity <- as.factor(lang_ECG$Familiarity)
str(lang_ECG)
```

```
## 'data.frame':    426 obs. of  7 variables:
##  $ Participant: Factor w/ 29 levels "10","14","17",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ Phase      : Factor w/ 2 levels "familiarization",..: 1 1 1 1 2 2 2 2 2 2 ...
##  $ Familiarity: Factor w/ 3 levels "familiar","famphase",..: 2 2 2 2 3 1 1 3 1 1 ...
##  $ LT         : num  1.17 2.65 15.26 11.68 5.49 ...
##  $ PC1        : num  -0.572 -0.572 -0.572 -0.572 -0.572 ...
##  $ PC2        : num  -0.092 -0.092 -0.092 -0.092 -0.092 ...
##  $ PC3        : num  -2.25 -2.25 -2.25 -2.25 -2.25 ...
```

```
#select only the data of the test phase
lang_ECG <- subset(lang_ECG, lang_ECG$Phase !="familiarization")

summary(lang_ECG)
```

```
##   Participant              Phase       Familiarity        LT
##  14     : 12   familiarization:  0   familiar:160   Min.   : 1.059
##  19     : 12   testing        :310   famphase:  0   1st Qu.: 3.378
##  30     : 12                         novel   :150   Median : 5.938
##  32     : 12                                        Mean   : 7.893
##  33     : 12                                        3rd Qu.:10.002
##  37     : 12                                        Max.   :31.696
##  (Other):238
##       PC1                PC2                 PC3
##  Min.   :-4.8247   Min.   :-2.19475   Min.   :-2.25027
##  1st Qu.:-1.0780   1st Qu.:-0.76545   1st Qu.:-0.42031
##  Median :-0.2899   Median : 0.05161   Median : 0.20945
##  Mean   :-0.0308   Mean   : 0.01955   Mean   : 0.03938
##  3rd Qu.: 1.0833   3rd Qu.: 0.78577   3rd Qu.: 0.57058
##  Max.   : 5.3849   Max.   : 2.03139   Max.   : 1.40010
##
```

```
#set contrasts
library(stats)
levels(droplevels(lang_ECG$Familiarity))
```

```
## [1] "familiar" "novel"
```

```
contrasts(lang_ECG$Familiarity)
```

```
##          famphase novel
## familiar        0     0
## famphase        1     0
## novel           0     1
```

```
#center predictors
lang_ECG$pc1C <- lang_ECG$PC1 - mean(lang_ECG$PC1)
lang_ECG$pc2C <- lang_ECG$PC2 - mean(lang_ECG$PC2)
```

Mixed models

```r
library(lme4)
```

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

```r
library(lmerTest)
```

```
## Warning: package 'lmerTest' was built under R version 4.0.5
```

```
##
## Attaching package: 'lmerTest'
```

```
## The following object is masked from 'package:lme4':
##
##     lmer
```

```
## The following object is masked from 'package:stats':
##
##     step
```

```r
options(scipen = 999)
lang_ECG$Familiarity <- relevel(lang_ECG$Familiarity, ref = "familiar")
```

```r
#run different models
pc0 =lmer(log(LT)~Familiarity+(1|Participant), data=lang_ECG, REML=FALSE)
pc1=lmer(log(LT)~Familiarity*pc1C+(1|Participant), data=lang_ECG, REML=FALSE)
pc2=lmer(log(LT)~Familiarity*pc1C+Familiarity*pc2C+(1|Participant), data=lang_ECG, REML=FALSE)
#compare models with Anova
anova(pc0,pc1,pc2)
```

```
## Data: lang_ECG
## Models:
## pc0: log(LT) ~ Familiarity + (1 | Participant)
## pc1: log(LT) ~ Familiarity * pc1C + (1 | Participant)
## pc2: log(LT) ~ Familiarity * pc1C + Familiarity * pc2C + (1 | Participant)
##     npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## pc0    4 689.45 704.39 -340.72   681.45
## pc1    6 693.34 715.76 -340.67   681.34 0.1029  2    0.94984
## pc2    8 691.46 721.35 -337.73   675.46 5.8801  2    0.05286 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
summary(pc2)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log(LT) ~ Familiarity * pc1C + Familiarity * pc2C + (1 | Participant)
##    Data: lang_ECG
##
##      AIC      BIC   logLik deviance df.resid
##    691.5    721.4   -337.7    675.5      302
```

```
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.02876 -0.61309 -0.07738  0.63312  2.50248
##
## Random effects:
##  Groups      Name        Variance Std.Dev.
##  Participant (Intercept) 0.1280   0.3578
##  Residual                0.4546   0.6743
## Number of obs: 310, groups:  Participant, 29
##
## Fixed effects:
##                        Estimate Std. Error         df t value
## (Intercept)            1.739135   0.085355  42.369320  20.375
## Familiaritynovel       0.051108   0.076938 281.615839   0.664
## pc1C                   0.011466   0.041902  42.172058   0.274
## pc2C                   0.028178   0.082346  41.993264   0.342
## Familiaritynovel:pc1C  0.003251   0.036957 280.777680   0.088
## Familiaritynovel:pc2C -0.174237   0.074902 281.417164  -2.326
##                                  Pr(>|t|)
## (Intercept)           <0.0000000000000002 ***
## Familiaritynovel                   0.5071
## pc1C                               0.7857
## pc2C                               0.7339
## Familiaritynovel:pc1C              0.9300
## Familiaritynovel:pc2C              0.0207 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Fmlrty pc1C   pc2C   Fml:1C
## Familrtynvl -0.434
## pc1C        -0.013  0.006
## pc2C         0.002  0.011  0.000
## Fmlrtynv:1C  0.006  0.000 -0.443 -0.001
## Fmlrtynv:2C  0.011  0.001 -0.001 -0.429 -0.018
```

#plot results

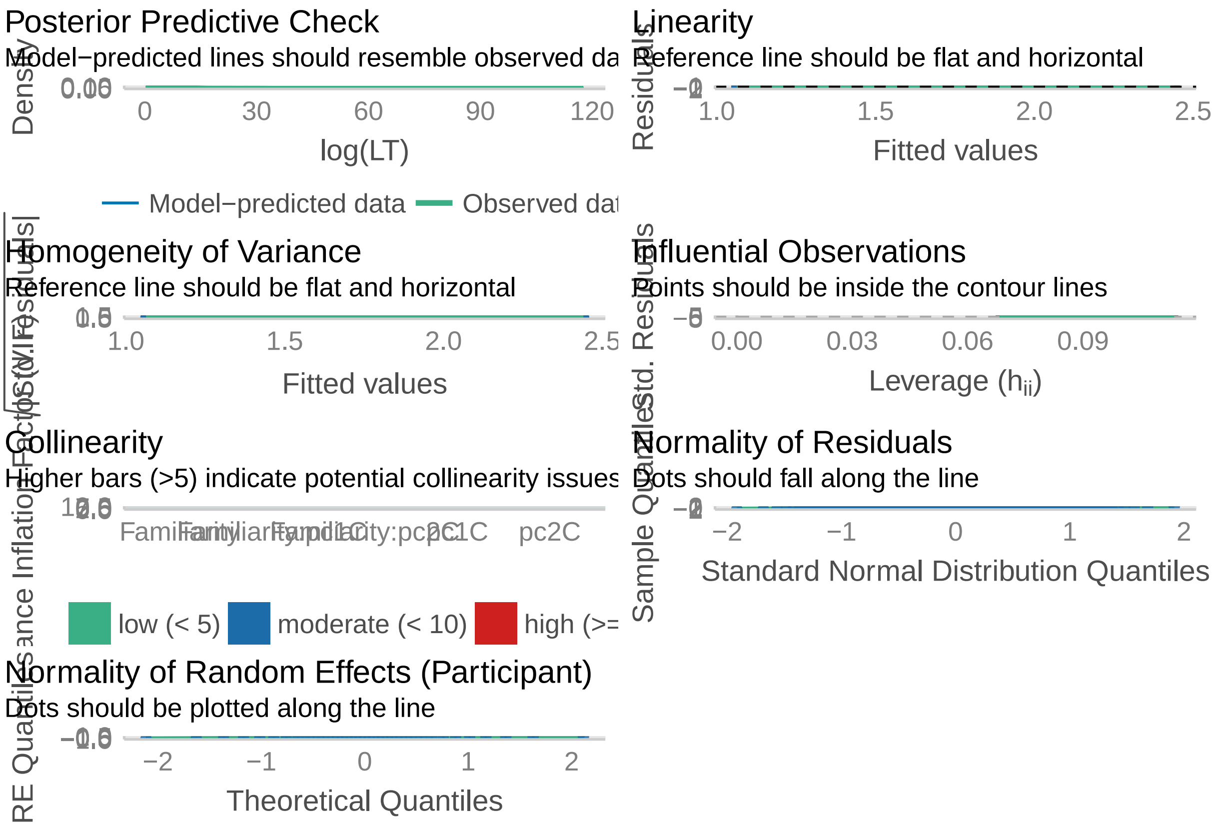
```
library(performance)
```

```
## Warning: package 'performance' was built under R version 4.0.5
```

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 4.0.5
```

```
check_model(pc2)
```




```
library(effects)
```

```
## Warning: package 'effects' was built under R version 4.0.5

## Loading required package: carData

## lattice theme set by effectsTheme()
## See ?effectsTheme for details.
```

```
myef <- effect("Familiarity*pc2C", pc2)
myef_df <- data.frame(myef)
head(myef_df)
```

```
##   Familiarity pc2C      fit         se    lower    upper
## 1    familiar -2.0 1.682780 0.18533732 1.318073 2.047486
## 2       novel -2.0 2.082363 0.18784213 1.712727 2.451998
## 3    familiar -1.0 1.710957 0.11847729 1.477818 1.944097
## 4       novel -1.0 1.936303 0.11953564 1.701081 2.171525
## 5    familiar -0.1 1.736317 0.08573388 1.567610 1.905024
## 6       novel -0.1 1.804849 0.08684260 1.633961 1.975738
```

```
ggplot(myef_df,aes(x=pc2C, y=fit, linetype=Familiarity, fill=Familiarity, size=Familiarity)) +
  geom_path(data=myef_df, aes(x=pc2C, y=fit), size=1.5) + # for plotting the lines
```

```
  geom_ribbon(data=myef_df, aes(x=pc2C, ymin=lower, ymax=upper, group=Familiarity), alpha=.3) +
  geom_point(data=lang_ECG, aes(x=pc2C, y=log(LT), shape=Familiarity, colour=Participant), size=1.5) +
  #scale_y_continuous(trans='logit') + # y-scale is now reflecting the logit space
  #theme_bw()
  #xlab("pc2 centered") + ylab("LT (fit)") +
  labs(x = "pc2 (centered)", y = "Log LT for test trials") +
  scale_fill_manual(values=c("black","black"))+
  guides(shape = guide_legend(title = "Trial type"), colour=FALSE, fill=FALSE, size=FALSE) +
  labs(linetype="Group")+
  theme(axis.title = element_text(size = 15), axis.text = element_text(size = 12),
        legend.text = element_text(size = 10), legend.title = element_text(size = 10))
```

```
## Warning: 'guides(<scale> = FALSE)' is deprecated. Please use 'guides(<scale> =
## "none")' instead.
```

```
## Warning: Using size for a discrete variable is not advised.
```