Reanalysis of 17-DePascalis

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Contents

Reference

De Pascalis, V., Fracasso, F., & Corr, P. J. (2017). Personality and Augmenting/Reducing (A/R) in auditory event-related potentials (ERPs) during emotional visual stimulation. Scientific Reports, 7, 41588. https://doi.org/10.1038/srep41588

Notes from reading methods section

- Dependant variable: "N1/P2 complex" (n = 39)

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- Independent variables:
  - Emotion, 3 levels (negative, neutral, positive pictures)
  - Auditory intensity, 5 levels (59, 70, 79, 88, 96 dB SPL)
  - Recording Site, 3 levels (frontal Fz, central Cz, parietal Pz)
- Covariate: BIS (Behavioural Inhibition System) with RST-PQ questionnaire
- Design: 3-way 3x5x3 ANCOVA (all factors within)

Reading data

Data is loaded, reshaped if necessary, and factors are specified.

```
PATH = file.path(path.expand("~"), "Data", "ancova") # ancova project folder
raw = read_excel(file.path(PATH, "dataPrimaryStudies", "17-DePascalis", "BIS_cov_N1-P2peak_amplitude_r.
raw = as.data.frame(raw)
# correcting typo
colnames(raw)[1] = "Subject"
```

Reshaping data into long

```
N = 39
data = data.frame(subject = as.factor(rep(raw$Subject, 3*5*3)))
data$amplitude = c(as.matrix(raw[,2:46]))
data$emotion   = as.factor(c(rep("negative", 5*3*N), rep("neutral", 5*3*N), rep("positive", 5*3*N)))
data$intensity = as.factor(rep(c(rep("level 1", 3*N), rep("level 2", 3*N), rep("level 3", 3*N), rep("le
data$site      = as.factor(rep(c(rep("location 1", N), rep("location 2", N), rep("location 3", N)), 3*5
data$bis       = rep(raw$RST_BIS, 3*5*3)
summary(data)
```

```
##     subject       amplitude          emotion      intensity           site
##  S01    :  45   Min.   : 2.322   negative:585   level 1:351   location 1:585
##  S02    :  45   1st Qu.:10.778   neutral :585   level 2:351   location 2:585
##  S03    :  45   Median :15.112   positive:585   level 3:351   location 3:585
##  S04    :  45   Mean   :17.944                  level 4:351
##  S05    :  45   3rd Qu.:22.039                  level 5:351
##  S06    :  45   Max.   :68.823
##  (Other):1485
##       bis
##  Min.   :33.00
##  1st Qu.:46.00
##  Median :53.00
##  Mean   :54.79
##  3rd Qu.:64.00
##  Max.   :81.00
##
```

Running an initial ANCOVA

Descriptives

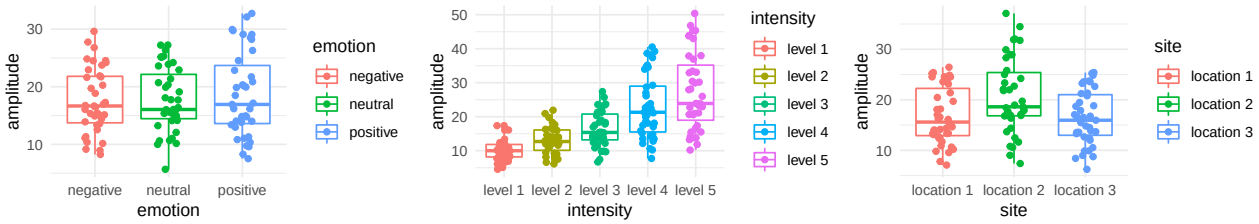
Dependent variable

We show descriptives plots and no tables as the factorial designs is rather complex (3x5x3).

Main effects

Averaging subjects across the other two levels

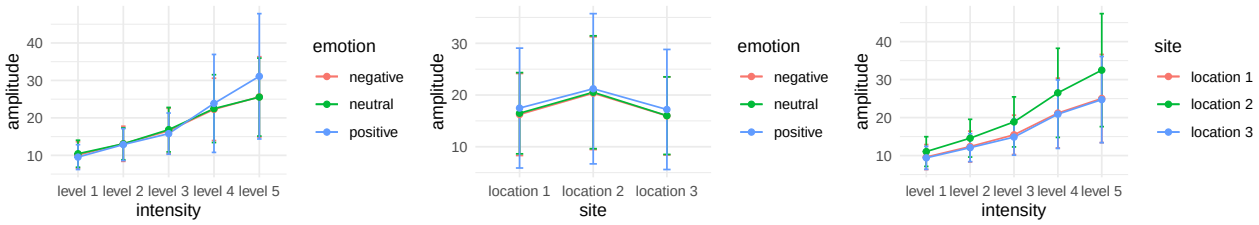
```
#
d.1 = aggregate(amplitude ~ bis + emotion*subject, data = data, FUN = mean)
d.2 = aggregate(amplitude ~ bis + intensity*subject, data = data, FUN = mean)
d.3 = aggregate(amplitude ~ bis + site*subject, data = data, FUN = mean)

p1 = ggplot(d.1, aes(y=amplitude, x=emotion, color=emotion)) +
  geom_boxplot() +
  geom_point(position = position_jitter(width = 0.15, height = 0)) +
  theme_minimal()

p2 = ggplot(d.2, aes(y=amplitude, x=intensity, color=intensity)) +
  geom_boxplot() +
  geom_point(position = position_jitter(width = 0.15, height = 0)) +
  theme_minimal()

p3 = ggplot(d.3, aes(y=amplitude, x=site, color=site)) +
  geom_boxplot() +
  geom_point(position = position_jitter(width = 0.15, height = 0)) +
  theme_minimal()

plot_grid(p1, p2, p3, nrow = 1, ncol = 3)
```



Interaction effects (two-way) Averaging subjects across along the third factor to see the two-way interactions. Plots show means (SD as error bar)

```
d.A = aggregate(amplitude ~ emotion*intensity, data = data, FUN = mean)
d.B = aggregate(amplitude ~ emotion*site, data = data, FUN = mean)
d.C = aggregate(amplitude ~ intensity*site, data = data, FUN = mean)

# get SD
d.A$sd = aggregate(amplitude ~ emotion*intensity, data = data, FUN = sd)[,3]
d.B$sd = aggregate(amplitude ~ emotion*site, data = data, FUN = sd)[,3]
d.C$sd = aggregate(amplitude ~ intensity*site, data = data, FUN = sd)[,3]

pA = ggplot(d.A, aes(y=amplitude, x=intensity, group=emotion, color=emotion)) +
  geom_errorbar(aes(ymin=amplitude-sd, ymax=amplitude+sd), width=.1) +
  geom_line() + geom_point() +
```

```
  theme_minimal()

pB = ggplot(d.B, aes(y=amplitude, x=site, group=emotion, color=emotion)) +
  geom_errorbar(aes(ymin=amplitude-sd, ymax=amplitude+sd), width=.1) +
  geom_line() + geom_point() +
  theme_minimal()

pC = ggplot(d.C, aes(y=amplitude, x=intensity, group=site, color=site)) +
  geom_errorbar(aes(ymin=amplitude-sd, ymax=amplitude+sd), width=.1) +
  geom_line() + geom_point() +
  theme_minimal()

plot_grid(pA, pB, pC, nrow = 1, ncol = 3)
```



Covariate(s)

Descriptives, see Table 1

```
sprintf("BIS: %0.1f (%0.1f)", mean(data$bis[1:N]), sd(data$bis[1:N]))
```

```
## [1] "BIS: 54.8 (11.8)"
```

Main analysis ANCOVA

```
# Orthogonal contrasts
# contrasts(data$group) = contr.helmert(2)

fit.ancova = aov(amplitude ~ bis + emotion*intensity*site + Error(subject/(emotion*intensity*site)), da
result = summary(fit.ancova) # Type I
#result = Anova(fit.ancova, type=3) # Type III
print(result)
```

```
##
## Error: subject
##           Df Sum Sq Mean Sq F value Pr(>F)
## bis        1   9585    9585   6.816  0.013 *
## Residuals 37  52027    1406
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:emotion
##           Df Sum Sq Mean Sq F value Pr(>F)
## emotion    2    423  211.74   4.533 0.0138 *
## Residuals 76   3550   46.71
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:intensity
##           Df Sum Sq Mean Sq F value Pr(>F)
## intensity   4  71397   17849   96.29 <2e-16 ***
## Residuals 152  28176     185
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:site
##           Df Sum Sq Mean Sq F value Pr(>F)
## site       2   6710    3355   68.75 <2e-16 ***
## Residuals 76   3709      49
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:emotion:intensity
##                    Df Sum Sq Mean Sq F value  Pr(>F)
## emotion:intensity   8   2252  281.51   8.319 3.3e-10 ***
## Residuals         304  10288   33.84
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:emotion:site
##               Df Sum Sq Mean Sq F value Pr(>F)
## emotion:site   4  16.75   4.188   2.682 0.0337 *
## Residuals    152 237.31   1.561
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:intensity:site
##                 Df Sum Sq Mean Sq F value Pr(>F)
## intensity:site   8   1871  233.86   50.06 <2e-16 ***
## Residuals      304   1420    4.67
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:emotion:intensity:site
##                         Df Sum Sq Mean Sq F value Pr(>F)
## emotion:intensity:site  16   22.8   1.426   1.022  0.431
## Residuals              608  848.8   1.396
```

Comparing ANCOVA in original study with reanalysis

Independant variable

```
tab.IV = rbind(stats.orig.IV, stats.rep.IV)
rownames(tab.IV) = c("original Study", "reanalysis")
print(t(tab.IV))
```

```
##         original Study reanalysis
```

```
## Fvalue              NA         NA
## df1                 NA         NA
## df2                 NA         NA
## pvalue              NA         NA
## MD                  NA         NA
## lowerCI             NA         NA
## upperCI             NA         NA
```

Covariate

```
tab.CV = rbind(stats.orig.CV.bis, stats.rep.CV.bis)
rownames(tab.CV) = c("original Study", "reanalysis")
print(t(tab.CV))
```

```
##         original Study reanalysis
## Fvalue  "6.82"         "6.82"
## df1     "1"            "1"
## df2     "37"           "37"
## pvalue  "0.013"        "0.013"
## MD      NA             NA
## lowerCI NA             NA
## upperCI NA             NA
```

Assumptions

1. Homogeneity of variance

- ANOVA/ANCOVA is fairly robust in terms of the error rate when sample sizes are equal.
- When groups with larger sample sizes have larger variances than the groups with smaller sample sizes, the resulting F-ratio tends to be conservative. That is, it's more likely to produce a non-significant result when a genuine difference does exist in the population.
- Conversely, when the groups with larger sample sizes have smaller variances than the groups with smaller samples sizes, the resulting F-ratio tends to be liberal and can inflate the false positive rate.

```
tmp = tapply(d.1$amplitude, d.1$emotion, sd)
tab = sprintf("%.2f", tmp)
names(tab) = names(tmp)
stats = leveneTest(amplitude ~ emotion, data = d.1)
tab[length(tab)+1] = formatPval(stats$`Pr(>F)`[1])
names(tab)[length(tab)] = "Levene's p-value"
print(tab)
```

```
##         negative          neutral         positive Levene's p-value
##           "5.61"           "5.47"           "7.27"           "0.12"
```

```
tmp = tapply(d.2$amplitude, d.2$intensity, sd)
tab = sprintf("%.2f", tmp)
names(tab) = names(tmp)
stats = leveneTest(amplitude ~ intensity, data = d.2)
tab[length(tab)+1] = formatPval(stats$`Pr(>F)`[1])
names(tab)[length(tab)] = "Levene's p-value"
print(tab)
```

```
##          level 1          level 2          level 3          level 4
##           "2.92"           "3.87"           "5.13"           "9.26"
##          level 5 Levene's p-value
##          "11.27"       "< 0.0001"
```

```
tmp = tapply(d.3$amplitude, d.3$site, sd)
tab = sprintf("%.2f", tmp)
names(tab) = names(tmp)
stats = leveneTest(amplitude ~ site, data = d.3)
tab[length(tab)+1] = formatPval(stats$`Pr(>F)`[1])
names(tab)[length(tab)] = "Levene's p-value"
print(tab)
```

```
##       location 1       location 2       location 3 Levene's p-value
##            "5.63"           "7.40"           "5.30"           "0.19"
```

2. Independence between covariate and IV

When the covariate and the experimental effect (independent variable) are not independent the treatment effect is obscured, spurious treatment effects can arise and the interpretation of the ANCOVA is seriously compromised.

We test whether our groups differ on the CV. If the groups do not significantly differ then is appropriate to use the covariate.

```
fit.cv = aov(bis ~ emotion, data = d.1)
summary(fit.cv)
```

```
##              Df Sum Sq Mean Sq F value Pr(>F)
## emotion       2      0     0.0       0      1
## Residuals   114  16003   140.4
```

Not applicable for a within design as the covariate does not change across levels. So this assumption does not need testing.

3. Homogeneity of regression slopes

- We test the interaction between the IV and the CV

```
fit.hrs = aov(amplitude ~ bis*emotion + Error(subject/emotion), data = d.1)
summary(fit.hrs)
```

```
##
## Error: subject
##           Df Sum Sq Mean Sq F value Pr(>F)
## bis        1    639   639.0   6.816  0.013 *
## Residuals 37   3468    93.7
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:emotion
##             Df Sum Sq Mean Sq F value  Pr(>F)
## emotion      2  28.23  14.116   4.944 0.00965 **
## bis:emotion  2  25.42  12.708   4.451 0.01495 *
## Residuals   74 211.27   2.855
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
fit.hrs = aov(amplitude ~ bis*intensity + Error(subject/intensity), data = d.2)
summary(fit.hrs)
```

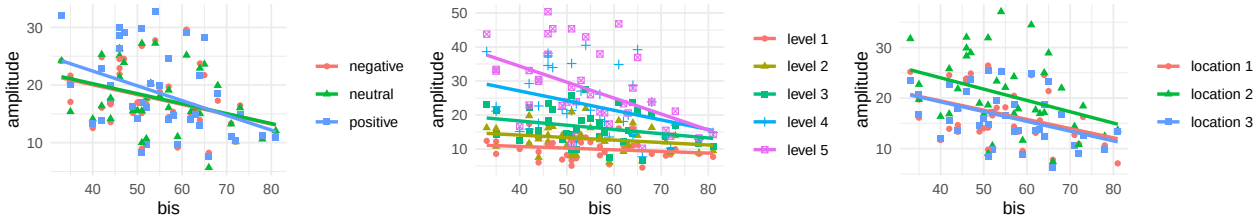
```
##
## Error: subject
##           Df Sum Sq Mean Sq F value Pr(>F)
## bis        1   1065  1065.0   6.816  0.013 *
## Residuals 37   5781   156.2
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:intensity
##                Df Sum Sq Mean Sq F value  Pr(>F)
## intensity       4   7933  1983.2 118.878 < 2e-16 ***
## bis:intensity   4    662   165.4   9.914 3.9e-07 ***
## Residuals     148   2469    16.7
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
fit.hrs = aov(amplitude ~ bis*site + Error(subject/site), data = d.3)
summary(fit.hrs)
```

```
##
## Error: subject
##           Df Sum Sq Mean Sq F value Pr(>F)
## bis        1    639   639.0   6.816  0.013 *
## Residuals 37   3468    93.7
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Error: subject:site
##           Df Sum Sq Mean Sq F value Pr(>F)
## site       2  447.4  223.68   68.31 <2e-16 ***
## bis:site   2    5.0    2.49    0.76  0.471
## Residuals 74  242.3    3.27
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
p1 = ggplot(d.1, aes(y=amplitude, x=bis, color=emotion, shape=emotion)) +
  geom_point() +
  geom_smooth(formula = y ~ x,method=lm, se=FALSE, fullrange=TRUE) +
  theme_minimal() +
  theme(legend.title = element_blank())

p2 = ggplot(d.2, aes(y=amplitude, x=bis, color=intensity, shape=intensity)) +
  geom_point() +
  geom_smooth(formula = y ~ x,method=lm, se=FALSE, fullrange=TRUE) +
  theme_minimal() +
  theme(legend.title = element_blank())

p3 = ggplot(d.3, aes(y=amplitude, x=bis, color=site, shape=site)) +
  geom_point() +
  geom_smooth(formula = y ~ x,method=lm, se=FALSE, fullrange=TRUE) +
```

```
  theme_minimal() +
  theme(legend.title = element_blank())

plot_grid(p1, p2, p3, ncol = 3, nrow = 1)
```



Notes

- Amplitudes were not normal, log transform could have had helped.
- The first reported ANCOVA result was reproduced: effect of the covariate BIS
- BIS was used as continuous covariate which showed a statistically sign. effect. on amplitude. However, authors reported an effect of low vs. high BIS participants on amplitude (categorical), with lower amplitudes in high BIS participants based on Figure 2.
- Not clear how low vs. high BIS was determined (which threshold was used?).
- Only parts of ANCOVA results were reported. There were altogether three main effects and three two-way interactions that were not all reported.
- Generally, there is a mismatch between the ANCOVA model specified and the result reported (BIS treated continuous or categorical?).
- Assumptions of homogeneity of regression slope was not met for intensity and emotion: the relationship between BIS and amplitude differed across levels of intensity and levels of emotion. The authors reported both, so this is fine.
- Assumption of independence between COV and IV cannot be tested in within-only designs.

Data was analyzed according to recommendations by Field, Miles, & Field (2012).