F06_mci_style_neu_additional_analyses.R

2023-08-07

```r
## MCI_STYLE_NEU ADDITIONAL ANALYSES ##

# This script contains additional control analyses in addition to the planned
# mixed models to control for semantic contexts instead of item as the random level.
# Both models are compared using a Likelihood Ratio Test.

## SETUP ## ----------------------------------------------------------------------------------------------------

# Load packages
library(MASS)          # Version 7.3-51.6
library(lme4)          # Version 1.1-23
library(lmerTest)      # Version 3.1-2
library(afex)          # Version 0.27-2
library(emmeans)       # Version 1.4.8
library(tidyverse)     # Version 1.3.0
library(magrittr)      # Version 1.5

# Load preprocessed data
a1 <- readRDS("EEG/export/a1.RDS")

# Remove trials with errors or invalid RTs/ERPs
a1 %<>% filter(!error) %>% na.omit()

# Center behavioral ratings (valence and arousal) around 0
a1 %<>% mutate(rating_1 = Rating1Resp - 2, rating_2 = Rating2Resp - 2)

# Define simple contrast coding for context narrative style (normal - fairytale)
#     H0(Intercept): (mu1+mu2)/2 = 0 <-> mu1+mu2 = 0
#     H0(Slope): -mu1 + mu2 = 0
```

```
#     with mu1 = mean of the normal style and mu2 = mean of the fairytale style
t(contrasts.style <- t(cbind(c("nor" = -1, "ftl" = 1))))
```

```
##     [,1]
## nor   -1
## ftl    1
```

```
contrasts(a1$style) <- ginv(contrasts.style)

# Define simple contrast coding for semantics (violation - intuitive, mci - intuitive)
#     H0(Intercept): (mu1+mu2+mu3)/3 = 0 <-> mu1+mu2+mu3 = 0
#     H0(Slope1): -1*mu1 +1*mu2 + 0*mu3 = 0
#     H0(Slope2): -1*mu1 +0*mu2 + 1*mu3 = 0
#     with mu1 = mean of intuitive concepts, mu2 = mean of violations, mu3 = mean of MCIs
t(contrasts.semantics <- t(cbind(c("int" = -1, "vio" = 1, "mci" = 0),
                                 c("int" = -1, "vio" = 0, "mci" = 1))))
```

```
##     [,1] [,2]
## int   -1   -1
## vio    1    0
## mci    0    1
```

```
contrasts(a1$semantics) <- ginv(contrasts.semantics)

## LINEAR MIXED-EFFECTS MODELS ## -----------------------------------------------------------------------------------

# Specifiy settings for optimization in lmer
control_params <- lmerControl(calc.derivs = FALSE, optimizer = "bobyqa", optCtrl = list(maxfun = 2e5))

# LMM for verb-related N400
mod_N400_verb <- lmer_alt(N400_verb ~ semantics*style + (semantics*style||participant) + (semantics*style||item),
                          data = a1, control = control_params)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
mod_N400_verb2 <- lmer_alt(N400_verb ~ semantics*style + (semantics*style||participant) + (semantics*style||item)+
                           (semantics*style||kontext_nr) ,
                         data = a1, control = control_params)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
anova(mod_N400_verb, mod_N400_verb2)
```

```
## refitting model(s) with ML (instead of REML)
```

```
## Data: data
## Models:
## mod_N400_verb: N400_verb ~ semantics * style + (1 + re1.semantics1 + re1.semantics2 + re1.style1 + re1.semantics1_by_style1 + re1.seman
## mod_N400_verb2: N400_verb ~ semantics * style + (1 + re1.semantics1 + re1.semantics2 + re1.style1 + re1.semantics1_by_style1 + re1.sema
##                npar   AIC   BIC logLik deviance  Chisq Df Pr(>Chisq)
## mod_N400_verb    19 36710 36840 -18336    36672
## mod_N400_verb2   25 36718 36889 -18334    36668 4.4709  6     0.6132
```

```
# LMM for picture-related N400
mod_N400_pict <- lmer_alt(N400_pict ~ semantics*style + (semantics*style||participant) + (semantics*style||item),
                         data = a1, control = control_params)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
mod_N400_pict2 <- lmer_alt(N400_pict ~ semantics*style + (semantics*style||participant) + (semantics*style||item) +
                           (semantics*style||kontext_nr) ,
                         data = a1, control = control_params)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
anova(mod_N400_pict, mod_N400_pict2)
```

```
## refitting model(s) with ML (instead of REML)
```

```
## Data: data
## Models:
## mod_N400_pict: N400_pict ~ semantics * style + (1 + re1.semantics1 + re1.semantics2 + re1.style1 + re1.semantics1_by_style1 + re1.seman
## mod_N400_pict2: N400_pict ~ semantics * style + (1 + re1.semantics1 + re1.semantics2 + re1.style1 + re1.semantics1_by_style1 + re1.sema
##                npar   AIC   BIC logLik deviance  Chisq Df Pr(>Chisq)
## mod_N400_pict    19 40403 40533 -20182    40365
## mod_N400_pict2   25 40384 40555 -20167    40334 31.032  6    2.5e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Create a list of all four models
models <- list("N400_VERB" = mod_N400_verb,
               "N400_VERB2" = mod_N400_verb2, "N400_PICT" = mod_N400_pict,
               "N400_PICT2" = mod_N400_pict2)

# F-tests (type III tests)
(tests <- map(models, anova))
```

```
## $N400_VERB
## Type III Analysis of Variance Table with Satterthwaite's method
##                 Sum Sq Mean Sq NumDF   DenDF F value Pr(>F)
## semantics       49.615  24.808     2 167.038  2.1461 0.1202
## style           12.252  12.252     1  49.762  1.0599 0.3082
## semantics:style 36.095  18.047     2  58.826  1.5613 0.2184
##
## $N400_VERB2
## Type III Analysis of Variance Table with Satterthwaite's method
##                 Sum Sq Mean Sq NumDF  DenDF F value  Pr(>F)
## semantics       56.421  28.211     2 6744.3  2.4454 0.08677 .
## style           10.830  10.830     1   40.7  0.9388 0.33831
## semantics:style 35.961  17.980     2   52.6  1.5586 0.21999
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $N400_PICT
## Type III Analysis of Variance Table with Satterthwaite's method
##                  Sum Sq Mean Sq NumDF  DenDF F value   Pr(>F)
## semantics        73.377  36.688     2   75.8  1.8929 0.157685
## style           134.130 134.130     1 6692.5  6.9202 0.008542 **
```

```
## semantics:style 185.370  92.685     2   82.2  4.7819 0.010851 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $N400_PICT2
## Type III Analysis of Variance Table with Satterthwaite's method
##                 Sum Sq Mean Sq NumDF  DenDF F value   Pr(>F)
## semantics       124.09  62.044     2   42.4  3.2039 0.050601 .
## style           134.74 134.736     1 6707.4  6.9577 0.008365 **
## semantics:style 184.34  92.172     2   82.4  4.7597 0.011064 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## PLANNED FOLLOW-UP CONTRASTS ## ----------------------------------------------------------------------------------------

# Allow emmeans to compute Satterthwaites p-values
emm_options(lmer.df = "Satterthwaite", lmerTest.limit = Inf)

# Follow-up contrasts for the main effect of semantics
(means.semantics <- map(models,function(x){
  emmeans(x, trt.vs.ctrl ~ semantics, infer = TRUE, adjust = "bonferroni")$contrasts
  }))
```

```
## NOTE: Results may be misleading due to involvement in interactions

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## $N400_VERB
##  contrast  estimate    SE     df lower.CL upper.CL t.ratio p.value
##  vio - int    0.020 0.100 6757.9   -0.205   0.2449   0.199  1.0000
##  mci - int   -0.181 0.105   81.3   -0.421   0.0593  -1.719  0.1787
##
## Results are averaged over the levels of: style
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
```

```
## P value adjustment: bonferroni method for 2 tests
##
## $N400_VERB2
##  contrast  estimate  SE   df lower.CL upper.CL t.ratio p.value
##  vio - int   0.0216 0.1 6744   -0.203   0.2462   0.216  1.0000
##  mci - int  -0.1800 0.1 6725   -0.404   0.0443  -1.800  0.1440
##
## Results are averaged over the levels of: style
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## P value adjustment: bonferroni method for 2 tests
##
## $N400_PICT
##  contrast  estimate    SE   df lower.CL upper.CL t.ratio p.value
##  vio - int   0.0229 0.192 57.2   -0.420   0.4655   0.119  1.0000
##  mci - int  -0.3524 0.189 40.6   -0.793   0.0884  -1.861  0.1400
##
## Results are averaged over the levels of: style
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## P value adjustment: bonferroni method for 2 tests
##
## $N400_PICT2
##  contrast  estimate    SE   df lower.CL upper.CL t.ratio p.value
##  vio - int   0.0241 0.141 43.2   -0.303   0.3515   0.171  1.0000
##  mci - int  -0.3554 0.157 24.9   -0.729   0.0179  -2.270  0.0642
##
## Results are averaged over the levels of: style
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## P value adjustment: bonferroni method for 2 tests
```

```r
# Follow-up contrasts for the main effect of context style
(means.style <- map(models, function(x){
  emmeans(x, trt.vs.ctrl ~ style, infer = TRUE, adjust = "bonferroni")$contrasts
  }))
```

```
## NOTE: Results may be misleading due to involvement in interactions
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```

```
## $N400_VERB
##  contrast  estimate     SE   df lower.CL upper.CL t.ratio p.value
##  ftl - nor  -0.0857 0.0832 49.8   -0.253   0.0815  -1.030  0.3082
##
## Results are averaged over the levels of: semantics
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
##
## $N400_VERB2
##  contrast  estimate     SE   df lower.CL upper.CL t.ratio p.value
##  ftl - nor  -0.0857 0.0884 40.7   -0.264   0.0929  -0.969  0.3383
##
## Results are averaged over the levels of: semantics
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
##
## $N400_PICT
##  contrast  estimate    SE   df lower.CL upper.CL t.ratio p.value
##  ftl - nor    0.279 0.106 6692    0.071    0.486   2.631  0.0085
##
## Results are averaged over the levels of: semantics
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
##
## $N400_PICT2
##  contrast  estimate    SE   df lower.CL upper.CL t.ratio p.value
##  ftl - nor    0.279 0.106 6707   0.0717    0.487   2.638  0.0084
##
## Results are averaged over the levels of: semantics
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
```

```r
# Follow-up contrasts for semantics within each context style
(means.nested <- map(models, function(x){
  emmeans(x, trt.vs.ctrl ~ semantics|style, infer = TRUE, adjust = "bonferroni")$contrasts
  }))
```

```
## $N400_VERB
## style = nor:
##  contrast  estimate    SE    df lower.CL upper.CL t.ratio p.value
##  vio - int  -0.0241 0.146 294.2   -0.352   0.3041  -0.165  1.0000
##  mci - int  -0.3805 0.156  90.7   -0.736  -0.0251  -2.440  0.0332
##
## style = ftl:
##  contrast  estimate    SE    df lower.CL upper.CL t.ratio p.value
##  vio - int   0.0640 0.146 295.6   -0.265   0.3925   0.439  1.0000
##  mci - int   0.0192 0.156  90.3   -0.336   0.3743   0.123  1.0000
##
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## P value adjustment: bonferroni method for 2 tests
##
## $N400_VERB2
## style = nor:
##  contrast  estimate    SE  df lower.CL upper.CL t.ratio p.value
##  vio - int  -0.0219 0.144 244   -0.346   0.3022  -0.153  1.0000
##  mci - int  -0.3799 0.153 107   -0.727  -0.0326  -2.487  0.0288
##
## style = ftl:
##  contrast  estimate    SE  df lower.CL upper.CL t.ratio p.value
##  vio - int   0.0651 0.144 245   -0.259   0.3896   0.453  1.0000
##  mci - int   0.0199 0.153 107   -0.327   0.3668   0.130  1.0000
##
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## P value adjustment: bonferroni method for 2 tests
##
## $N400_PICT
```

```
## style = nor:
##  contrast  estimate    SE   df lower.CL upper.CL t.ratio p.value
##  vio - int   -0.221 0.240 91.6   -0.769    0.327  -0.920  0.7198
##  mci - int   -0.751 0.230 87.8   -1.275   -0.227  -3.270  0.0031
##
## style = ftl:
##  contrast  estimate    SE   df lower.CL upper.CL t.ratio p.value
##  vio - int    0.267 0.241 91.7   -0.281    0.815   1.110  0.5399
##  mci - int    0.046 0.229 87.5   -0.477    0.569   0.201  1.0000
##
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## P value adjustment: bonferroni method for 2 tests
##
## $N400_PICT2
## style = nor:
##  contrast  estimate    SE   df lower.CL upper.CL t.ratio p.value
##  vio - int  -0.2184 0.202 76.2   -0.679    0.243  -1.083  0.5641
##  mci - int  -0.7528 0.203 71.0   -1.218   -0.287  -3.703  0.0008
##
## style = ftl:
##  contrast  estimate    SE   df lower.CL upper.CL t.ratio p.value
##  vio - int   0.2666 0.202 76.2   -0.195    0.728   1.321  0.3807
##  mci - int   0.0421 0.203 70.7   -0.423    0.507   0.207  1.0000
##
## Degrees-of-freedom method: satterthwaite
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## P value adjustment: bonferroni method for 2 tests
```

```r
# Backup results
save(models, tests, means.semantics, means.style, means.nested, file = "EEG/export/stats.RData")

# System specs and package versions
sessionInfo()
```

```
## R version 4.3.1 (2023-06-16)
## Platform: x86_64-apple-darwin20 (64-bit)
```

```
## Running under: macOS Ventura 13.4.1
##
## Matrix products: default
## BLAS:   /System/Library/Frameworks/Accelerate.framework/Versions/A/Frameworks/vecLib.framework/Versions/A/libBLAS.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.3-x86_64/Resources/lib/libRlapack.dylib;  LAPACK version 3.11.0
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: Europe/Berlin
## tzcode source: internal
##
## attached base packages:
## [1] stats     graphics  grDevices datasets  utils     methods   base
##
## other attached packages:
##  [1] magrittr_2.0.3  lubridate_1.9.2 forcats_1.0.0   stringr_1.5.0   dplyr_1.1.2
##  [6] purrr_1.0.1     readr_2.1.4     tidyr_1.3.0     tibble_3.2.1    ggplot2_3.4.2
## [11] tidyverse_2.0.0 emmeans_1.8.7   afex_1.3-0      lmerTest_3.1-3  lme4_1.1-34
## [16] Matrix_1.6-0    MASS_7.3-60
##
## loaded via a namespace (and not attached):
##  [1] generics_0.1.3      utf8_1.2.3          renv_0.12.0         stringi_1.7.12
##  [5] lattice_0.21-8      hms_1.1.3           digest_0.6.33       timechange_0.2.0
##  [9] evaluate_0.21       grid_4.3.1          estimability_1.4.1  mvtnorm_1.2-2
## [13] fastmap_1.1.1       plyr_1.8.8          fansi_1.0.4         scales_1.2.1
## [17] numDeriv_2016.8-1.1 abind_1.4-5         cli_3.6.1           rlang_1.1.1
## [21] munsell_0.5.0       splines_4.3.1       withr_2.5.0         yaml_2.3.7
## [25] tools_4.3.1         parallel_4.3.1      tzdb_0.4.0          reshape2_1.4.4
## [29] nloptr_2.0.3        minqa_1.2.5         colorspace_2.1-0    boot_1.3-28.1
## [33] vctrs_0.6.3         R6_2.5.1            lifecycle_1.0.3     car_3.1-2
## [37] pkgconfig_2.0.3     pillar_1.9.0        gtable_0.3.3        glue_1.6.2
## [41] Rcpp_1.0.11         tidyselect_1.2.0    xfun_0.39           rstudioapi_0.15.0
## [45] knitr_1.43          htmltools_0.5.5     nlme_3.1-162        rmarkdown_2.23
## [49] carData_3.0-5       compiler_4.3.1
```