M21 202303 n250 lme

Joanna Morris

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This R script contains the code for analysing the morph 21 erp data for the 200-300 ms time window.

1. First we load the libraries we need

```
library(readr)
library(psych)
library(dplyr)
library(tidyr)
library(ggplot2)
```

Let's load the N250 erp data file and the spelling and vocab data, then we join the files. We will use the `inner_join` rather than the `full_join` function in order to eliminate rows with missing data.

```
sv_202303.na <- read_csv("m21_spell_vocab_raw_z_pca.csv", show_col_types = FALSE)
n250 <- read_csv("S101-177_n250.csv", show_col_types = FALSE)
n250 <- inner_join(sv_202303.na,n250, by = "SubjID")  #join subject PCA data
```

Let's save a `.csv` file with the data from the combined dataset

```
write_csv(n250, "202303_sv_n250_rmna.csv")
```

We will create a subset with only the electrode sites we will be analysing—F3, Fz, F4, C3, Cz, C4, P3, Pz, P4

```
sites = c(3,2, 25, 7, 20, 21, 12, 11, 16)
n250_9 <- dplyr::filter(n250, chindex %in% sites)
```

7. We then create separate columns, one for each independent variable (anteriority, laterality, morphological family size). To do this we have to use the`mutate` function from the dplyr package along with the `case_when` function. The `case_when` function is a sequence of two-sided formulas. The left hand side determines which values match this case. The right hand side provides the replacement value.

```
n250_9 <- dplyr::mutate(n250_9,
                        anteriority = case_when(grepl("F", chlabel) ~ "Frontal",
                                                grepl("C", chlabel) ~ "Central",
                                                grepl("P", chlabel) ~ "Parietal"))

n250_9 <- dplyr::mutate(n250_9,
                        laterality = case_when(grepl("3", chlabel) ~ "Left",
```

```
                                                grepl("z", chlabel) ~ "Midline",
                                                grepl("Z", chlabel) ~ "Midline",
                                                grepl("4", chlabel) ~ "Right"))



n250_9 <- dplyr::mutate(n250_9,
                        fam_size = case_when(grepl("small", binlabel) ~ "Small",
                                             grepl("large", binlabel) ~ "Large"))
```

8. We then create a smaller dataset with only the columns we need

```
n250_9b <- dplyr::select(n250_9,
                             SubjID,
                             lang_type,
                             anteriority,
                             laterality,
                             fam_size,
                             value,
                             chlabel,
                             binlabel)
```

9. We then divide dataset into 3 separate ones—for "words", "simple nonwords" and "complex nonwords"

```
n250_words <- dplyr::filter(n250_9b, grepl("Critical_word",binlabel))
n250_nwsmpl <- dplyr::filter(n250_9b, grepl("simple",binlabel))
n250_nwcplx <- dplyr::filter(n250_9b, grepl("complex",binlabel))
```

#Plot Means

Get condition means

```
#Define standard error of the mean function

sem <- function(x) sd(x)/sqrt(length(x))

(cw.cond.means <- n250_words |>
   group_by(fam_size, lang_type) |>
   summarise(mean = mean(value),
             se = sem(value),
             num_stim = n()))
```

```
# A tibble: 4 x 5
# Groups:   fam_size [2]
  fam_size lang_type       mean    se num_stim
  <chr>    <chr>          <dbl> <dbl>    <int>
1 Large    Orthographic  0.0725 0.213      270
2 Large    Semantic     -0.577  0.175      234
3 Small    Orthographic  0.298  0.219      270
4 Small    Semantic     -0.338  0.196      234
```

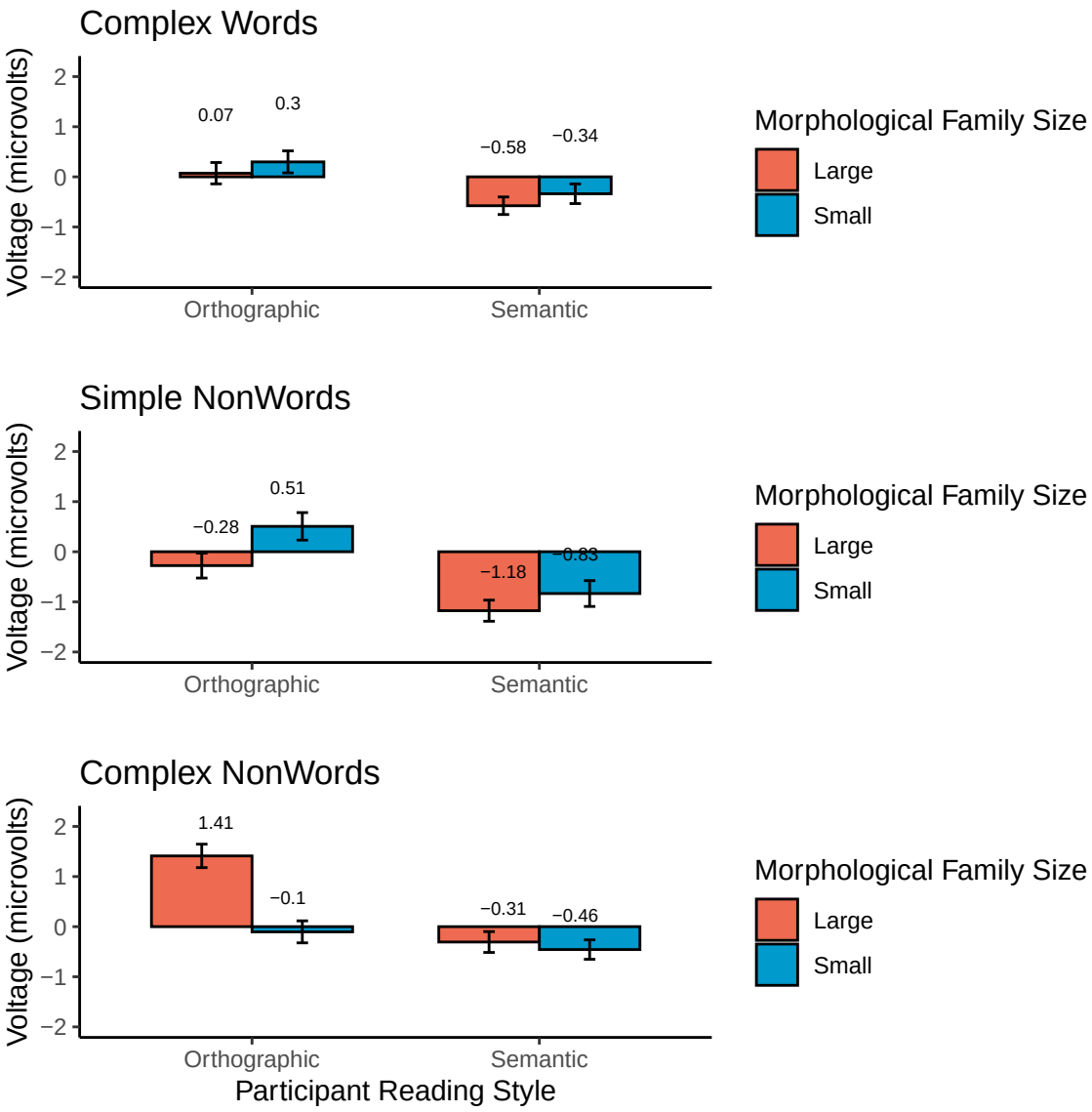
```
(nw_smp.cond.means <- n250_nwsmpl |>
    group_by(fam_size, lang_type) |>
    summarise(mean = mean(value),
              se = sem(value),
              num_stim = n()))
```

```
# A tibble: 4 x 5
# Groups:   fam_size [2]
  fam_size lang_type      mean    se num_stim
  <chr>    <chr>         <dbl> <dbl>    <int>
1 Large    Orthographic -0.277 0.248      270
2 Large    Semantic     -1.18  0.211      234
3 Small    Orthographic  0.506 0.275      270
4 Small    Semantic     -0.834 0.257      234
```

```
(nw_cpx.cond.means <- n250_nwcplx |>
    group_by(fam_size, lang_type) |>
    summarise(mean = mean(value),
              se = sem(value),
              num_stim = n()))
```

```
# A tibble: 4 x 5
# Groups:   fam_size [2]
  fam_size lang_type      mean    se num_stim
  <chr>    <chr>         <dbl> <dbl>    <int>
1 Large    Orthographic  1.41  0.234      270
2 Large    Semantic     -0.306 0.208      234
3 Small    Orthographic -0.104 0.219      270
4 Small    Semantic     -0.457 0.194      234
```

Barplots



LME

```
library(lme4)
```

COMPLEX WORDS

```
cw_null.model = lmer(value ~ 1 + (1|SubjID) ,
                     data= n250_words, REML=FALSE)
summary(cw_null.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
```

```
Formula: value ~ 1 + (1 | SubjID)
   Data: n250_words

     AIC      BIC   logLik deviance df.resid
  4555.6   4570.4  -2274.8   4549.6     1005

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.2085 -0.6434 -0.0517  0.5876  3.5597

Random effects:
 Groups   Name        Variance Std.Dev.
 SubjID   (Intercept) 5.713    2.390
 Residual             4.490    2.119
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
            Estimate Std. Error t value
(Intercept)  -0.2065     0.3292  -0.627
```

```
# Main effects models with random intercepts
cw_main.model = lmer(value ~ lang_type + fam_size + (1 + fam_size|SubjID) ,
                     data= n250_words, REML=FALSE)
summary(cw_main.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
   Data: n250_words

     AIC      BIC   logLik deviance df.resid
  4356.7   4391.1  -2171.4   4342.7     1001

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.2594 -0.5430 -0.0442  0.5305  3.1336

Random effects:
 Groups   Name          Variance Std.Dev. Corr
 SubjID   (Intercept)   6.286    2.507
          fam_sizeSmall 4.843    2.201    -0.32
 Residual               3.212    1.792
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
                 Estimate Std. Error t value
(Intercept)       -0.08767    0.46429  -0.189
lang_typeSemantic -0.47973    0.65174  -0.736
fam_sizeSmall      0.21459    0.31765   0.676

Correlation of Fixed Effects:
            (Intr) lng_tS
lng_typSmnt -0.663
fam_sizSmll -0.262  0.000
```

```r
# Interaction effects models with random intercepts
cw_inter.model = lmer(value ~ lang_type * fam_size + (1 + fam_size|SubjID) ,
                      data= n250_words, REML=FALSE)
summary(cw_inter.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ lang_type * fam_size + (1 + fam_size | SubjID)
   Data: n250_words

     AIC      BIC   logLik deviance df.resid
  4358.7   4398.1  -2171.4   4342.7     1000

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.2590 -0.5432 -0.0442  0.5296  3.1340

Random effects:
 Groups   Name          Variance Std.Dev. Corr
 SubjID   (Intercept)   6.285    2.507
          fam_sizeSmall 4.842    2.200    -0.32
 Residual               3.212    1.792
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
                              Estimate Std. Error t value
(Intercept)                   -0.07928    0.47835  -0.166
lang_typeSemantic             -0.49750    0.69591  -0.715
fam_sizeSmall                  0.19271    0.43719   0.441
lang_typeSemantic:fam_sizeSmall  0.04635    0.63626   0.073

Correlation of Fixed Effects:
            (Intr) lng_tS fm_szS
lng_typSmnt -0.687
fam_sizSmll -0.350  0.241
lng_typS:_S  0.241 -0.351 -0.687
```

```r
anova(cw_null.model,cw_main.model)
```

```
Data: n250_words
Models:
cw_null.model: value ~ 1 + (1 | SubjID)
cw_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
              npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
cw_null.model    3 4555.6 4570.4 -2274.8   4549.6
cw_main.model    7 4356.7 4391.1 -2171.4   4342.7 206.91  4  < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
anova(cw_main.model,cw_inter.model)
```

```
Data: n250_words
Models:
```

```
cw_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
cw_inter.model: value ~ lang_type * fam_size + (1 + fam_size | SubjID)
               npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
cw_main.model     7 4356.7 4391.1 -2171.4   4342.7
cw_inter.model    8 4358.7 4398.1 -2171.4   4342.7 0.0053  1     0.9419
```

SIMPLE NONWORDS

```
nw.smpl_null.model = lmer(value ~ 1 + (1|SubjID) ,
                          data= n250_nwsmpl, REML=FALSE)
summary(nw.smpl_null.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ 1 + (1 | SubjID)
   Data: n250_nwsmpl

     AIC      BIC   logLik deviance df.resid
  5144.8   5159.6  -2569.4   5138.8     1005

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.6813 -0.5297  0.0084  0.5082  5.1466

Random effects:
 Groups   Name        Variance Std.Dev.
 SubjID   (Intercept) 8.104    2.847
 Residual             8.159    2.856
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
            Estimate Std. Error t value
(Intercept)  -0.4552     0.3944  -1.154
```

```
# Main effects models with random intercepts
nw.smpl_main.model = lmer(value ~ lang_type + fam_size + (1 + fam_size|SubjID) ,
                          data= n250_nwsmpl, REML=FALSE)
summary(nw.smpl_main.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
   Data: n250_nwsmpl

     AIC      BIC   logLik deviance df.resid
  4706.9   4741.3  -2346.4   4692.9     1001

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.0230 -0.5421 -0.0158  0.5006  4.6008

Random effects:
 Groups   Name          Variance Std.Dev. Corr
```

```
 SubjID   (Intercept)    9.734   3.120
          fam_sizeSmall 12.482   3.533    -0.44
 Residual                4.403   2.098
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
                  Estimate Std. Error t value
(Intercept)        -0.1740     0.5641  -0.308
lang_typeSemantic  -1.0279     0.7701  -1.335
fam_sizeSmall       0.4073     0.4945   0.824

Correlation of Fixed Effects:
            (Intr) lng_tS
lng_typSmnt -0.645
fam_sizSmll -0.345  0.000
```

```
# Interaction effects models with random intercepts
nw.smpl_inter.model = lmer(value ~ lang_type * fam_size + (1 + fam_size|SubjID) ,
                           data= n250_nwsmpl, REML=FALSE)
summary(nw.smpl_inter.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ lang_type * fam_size + (1 + fam_size | SubjID)
   Data: n250_nwsmpl

     AIC      BIC   logLik deviance df.resid
  4708.8   4748.2  -2346.4   4692.8     1000

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.0225 -0.5416 -0.0147  0.5016  4.6003

Random effects:
 Groups   Name          Variance Std.Dev. Corr
 SubjID   (Intercept)    9.734   3.120
          fam_sizeSmall 12.477   3.532    -0.44
 Residual                4.403   2.098
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
                             Estimate Std. Error t value
(Intercept)                   -0.1970     0.5935  -0.332
lang_typeSemantic             -0.9791     0.8634  -1.134
fam_sizeSmall                  0.4659     0.6807   0.684
lang_typeSemantic:fam_sizeSmall  -0.1239     0.9904  -0.125

Correlation of Fixed Effects:
            (Intr) lng_tS fm_szS
lng_typSmnt -0.687
fam_sizSmll -0.452  0.311
lng_typS:_S  0.311 -0.452 -0.687
```

```
anova(nw.smpl_null.model,nw.smpl_main.model)
```

```
Data: n250_nwsmpl
Models:
nw.smpl_null.model: value ~ 1 + (1 | SubjID)
nw.smpl_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
nw.smpl_null.model    3 5144.8 5159.6 -2569.4   5138.8
nw.smpl_main.model    7 4706.9 4741.3 -2346.4   4692.9 445.95  4  < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(nw.smpl_main.model,nw.smpl_inter.model)
```

```
Data: n250_nwsmpl
Models:
nw.smpl_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
nw.smpl_inter.model: value ~ lang_type * fam_size + (1 + fam_size | SubjID)
                    npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
nw.smpl_main.model     7 4706.9 4741.3 -2346.4   4692.9
nw.smpl_inter.model    8 4708.8 4748.2 -2346.4   4692.8 0.0157  1     0.9004
```

COMPLEX NONWORDS

```
nw.cplx_null.model = lmer(value ~ 1 + (1|SubjID) ,
                          data= n250_nwcplx, REML=FALSE)
summary(nw.cplx_null.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ 1 + (1 | SubjID)
   Data: n250_nwcplx

     AIC      BIC   logLik deviance df.resid
  4850.0   4864.8  -2422.0   4844.0     1005

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.7570 -0.6195 -0.0018  0.5511  4.5243

Random effects:
 Groups   Name        Variance Std.Dev.
 SubjID   (Intercept) 5.766    2.401
 Residual             6.106    2.471
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
            Estimate Std. Error t value
(Intercept)  0.07054    0.33308   0.212
```

```r
# Main effects models with random intercepts
nw.cplx_main.model = lmer(value ~ lang_type + fam_size + (1 + fam_size|SubjID) ,
                          data= n250_nwcplx, REML=FALSE)
summary(nw.cplx_main.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
   Data: n250_nwcplx

     AIC      BIC   logLik deviance df.resid
  4582.8   4617.2  -2284.4   4568.8     1001

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.6097 -0.5449 -0.0332  0.4656  4.5605

Random effects:
 Groups   Name          Variance Std.Dev. Corr
 SubjID   (Intercept)   7.256    2.694
          fam_sizeSmall 6.884    2.624    -0.47
 Residual               4.044    2.011
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
                  Estimate Std. Error t value
(Intercept)         0.8926     0.4860   1.837
lang_typeSemantic  -0.8805     0.6563  -1.342
fam_sizeSmall      -0.8138     0.3759  -2.165

Correlation of Fixed Effects:
            (Intr) lng_tS
lng_typSmnt -0.638
fam_sizSmll -0.372  0.000
```

```r
# Interaction effects models with random intercepts
nw.cplx_inter.model = lmer(value ~ lang_type * fam_size  + (1 + fam_size|SubjID),
                           data= n250_nwcplx, REML=FALSE)
summary(nw.cplx_inter.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ lang_type * fam_size + (1 + fam_size | SubjID)
   Data: n250_nwcplx

     AIC      BIC   logLik deviance df.resid
  4581.9   4621.2  -2283.0   4565.9     1000

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.5973 -0.5473 -0.0524  0.4676  4.5481

Random effects:
 Groups   Name          Variance Std.Dev. Corr
 SubjID   (Intercept)   7.161    2.676
```

```
          fam_sizeSmall 6.487    2.547    -0.45
 Residual               4.044    2.011
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
                               Estimate Std. Error t value
(Intercept)                     1.1777     0.5120   2.300
lang_typeSemantic              -1.4841     0.7449  -1.992
fam_sizeSmall                  -1.4071     0.5041  -2.791
lang_typeSemantic:fam_sizeSmall  1.2561     0.7336   1.712

Correlation of Fixed Effects:
            (Intr) lng_tS fm_szS
lng_typSmnt -0.687
fam_sizSmll -0.473  0.325
lng_typS:_S  0.325 -0.473 -0.687
```

```
anova(nw.cplx_null.model,nw.cplx_main.model)
```

```
Data: n250_nwcplx
Models:
nw.cplx_null.model: value ~ 1 + (1 | SubjID)
nw.cplx_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
nw.cplx_null.model    3 4850.0 4864.8 -2422.0   4844.0
nw.cplx_main.model    7 4582.8 4617.2 -2284.4   4568.8 275.25  4  < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(nw.cplx_main.model,nw.cplx_inter.model)
```

```
Data: n250_nwcplx
Models:
nw.cplx_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
nw.cplx_inter.model: value ~ lang_type * fam_size + (1 + fam_size | SubjID)
                    npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
nw.cplx_main.model     7 4582.8 4617.2 -2284.4   4568.8
nw.cplx_inter.model    8 4581.9 4621.2 -2282.9   4565.9 2.8546  1    0.09111 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Model Comparisons

```
anova(cw_null.model,cw_main.model)
```

```
Data: n250_words
Models:
cw_null.model: value ~ 1 + (1 | SubjID)
cw_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
               npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
```

```
cw_null.model    3 4555.6 4570.4 -2274.8   4549.6
cw_main.model    7 4356.7 4391.1 -2171.4   4342.7 206.91  4  < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(cw_main.model,cw_inter.model)
```

```
Data: n250_words
Models:
cw_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
cw_inter.model: value ~ lang_type * fam_size + (1 + fam_size | SubjID)
              npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
cw_main.model     7 4356.7 4391.1 -2171.4   4342.7
cw_inter.model    8 4358.7 4398.1 -2171.4   4342.7 0.0053  1     0.9419
```

```
anova(nw.smpl_null.model,nw.smpl_main.model)
```

```
Data: n250_nwsmpl
Models:
nw.smpl_null.model: value ~ 1 + (1 | SubjID)
nw.smpl_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
nw.smpl_null.model    3 5144.8 5159.6 -2569.4   5138.8
nw.smpl_main.model    7 4706.9 4741.3 -2346.4   4692.9 445.95  4  < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(nw.smpl_main.model,nw.smpl_inter.model)
```

```
Data: n250_nwsmpl
Models:
nw.smpl_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
nw.smpl_inter.model: value ~ lang_type * fam_size + (1 + fam_size | SubjID)
                    npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
nw.smpl_main.model     7 4706.9 4741.3 -2346.4   4692.9
nw.smpl_inter.model    8 4708.8 4748.2 -2346.4   4692.8 0.0157  1     0.9004
```

```
anova(nw.cplx_null.model,nw.cplx_main.model)
```

```
Data: n250_nwcplx
Models:
nw.cplx_null.model: value ~ 1 + (1 | SubjID)
nw.cplx_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
nw.cplx_null.model    3 4850.0 4864.8 -2422.0   4844.0
nw.cplx_main.model    7 4582.8 4617.2 -2284.4   4568.8 275.25  4  < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(nw.cplx_main.model,nw.cplx_inter.model)
```

```
Data: n250_nwcplx
Models:
nw.cplx_main.model: value ~ lang_type + fam_size + (1 + fam_size | SubjID)
nw.cplx_inter.model: value ~ lang_type * fam_size + (1 + fam_size | SubjID)
                    npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
nw.cplx_main.model     7 4582.8 4617.2 -2284.4   4568.8
nw.cplx_inter.model    8 4581.9 4621.2 -2282.9   4565.9 2.8546  1    0.09111 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# COMPLEX WORDS

cw_null.model = lmer(value ~ 1 + (1|SubjID) ,
                     data= n250_words, REML=FALSE)
summary(cw_null.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ 1 + (1 | SubjID)
   Data: n250_words

     AIC      BIC   logLik deviance df.resid
  4555.6   4570.4  -2274.8   4549.6     1005

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.2085 -0.6434 -0.0517  0.5876  3.5597

Random effects:
 Groups   Name        Variance Std.Dev.
 SubjID   (Intercept) 5.713    2.390
 Residual             4.490    2.119
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
            Estimate Std. Error t value
(Intercept)  -0.2065     0.3292  -0.627
```

```
# Main effects models with random intercepts
cw_main.model = lmer(value ~ lang_type + (1 |SubjID) ,
                     data= n250_words, REML=FALSE)
summary(cw_main.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ lang_type + (1 | SubjID)
   Data: n250_words

     AIC      BIC   logLik deviance df.resid
  4557.1   4576.8  -2274.6   4549.1     1004

Scaled residuals:
```

```
    Min      1Q  Median      3Q     Max
-4.2137 -0.6430 -0.0487  0.5896  3.5544

Random effects:
 Groups   Name        Variance Std.Dev.
 SubjID   (Intercept) 5.656    2.378
 Residual             4.490    2.119
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
                  Estimate Std. Error t value
(Intercept)         0.0182     0.4511   0.040
lang_typeSemantic  -0.4755     0.6562  -0.725

Correlation of Fixed Effects:
            (Intr)
lng_typSmnt -0.687
```

```
anova(cw_null.model,cw_main.model)
```

```
Data: n250_words
Models:
cw_null.model: value ~ 1 + (1 | SubjID)
cw_main.model: value ~ lang_type + (1 | SubjID)
              npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
cw_null.model    3 4555.6 4570.4 -2274.8   4549.6
cw_main.model    4 4557.1 4576.8 -2274.6   4549.1 0.5224  1     0.4698
```

```
# COMPLEX WORDS

cw_null.model = lmer(value ~ 1 + (1|SubjID) ,
                     data= n250_words, REML=FALSE)
summary(cw_null.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ 1 + (1 | SubjID)
   Data: n250_words

     AIC      BIC   logLik deviance df.resid
  4555.6   4570.4  -2274.8   4549.6     1005

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.2085 -0.6434 -0.0517  0.5876  3.5597

Random effects:
 Groups   Name        Variance Std.Dev.
 SubjID   (Intercept) 5.713    2.390
 Residual             4.490    2.119
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
            Estimate Std. Error t value
(Intercept)  -0.2065     0.3292  -0.627
```

```r
# Main effects models with random intercepts
cw_main.model = lmer(value ~ fam_size + (1 |SubjID) ,
                     data= n250_words, REML=FALSE)
summary(cw_main.model)
```

```
Linear mixed model fit by maximum likelihood  ['lmerMod']
Formula: value ~ fam_size + (1 | SubjID)
   Data: n250_words

     AIC      BIC   logLik deviance df.resid
  4554.6   4574.3  -2273.3   4546.6     1004

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.1601 -0.6427 -0.0446  0.6039  3.5108

Random effects:
 Groups   Name        Variance Std.Dev.
 SubjID   (Intercept) 5.714    2.390
 Residual             4.476    2.116
Number of obs: 1008, groups:  SubjID, 55

Fixed effects:
             Estimate Std. Error t value
(Intercept)    -0.3225     0.3359   -0.96
fam_sizeSmall   0.2319     0.1333    1.74

Correlation of Fixed Effects:
            (Intr)
fam_sizSmll -0.198
```

```r
anova(cw_null.model,cw_main.model)
```

```
Data: n250_words
Models:
cw_null.model: value ~ 1 + (1 | SubjID)
cw_main.model: value ~ fam_size + (1 | SubjID)
              npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
cw_null.model    3 4555.6 4570.4 -2274.8   4549.6
cw_main.model    4 4554.6 4574.3 -2273.3   4546.6 3.024  1    0.08204 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```