# M21 RT Orthographic Sensitivity

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## Setup

Load libraries

1. Set ggplot2 parameters

## Load Files and Format Files

### Load Files

```
#DIR <- "csv_files"
df_a <- read_csv("rt_data_hc_A.csv")
df_b <- read_csv( "rt_data_hc_B_fixed.csv")
frq_w <- read_csv("frq_cw.csv")
frq_nw <- read_csv("frq_nw.csv")
dmg <- read_csv("demo_lang_vsl_pca_hc.csv")
```

### Format Files

```
# Concatenate datasets
rt <- bind_rows(AB = df_a,
                BA = df_b,
               .id = "List")
rt_dmg<- right_join(dmg, rt, join_by(SubjID == subject_nr)) |>  # Join Participant Demographic and Lang Data
                    mutate(target = tolower(target)) |>
                    filter(correct == 1)

# Divide into Experimental and Filler Items
rt_fill <- rt_dmg |> filter(str_detect(targ_type, "^FILL"))
rt_exp <- rt_dmg |> filter(!str_detect(targ_type, "^FILL"))

# Add logFS to frequency datasets
frq_w <- frq_w |> mutate(Log10FS = log10(FS))
frq_nw <- frq_nw |> mutate(Log10FS = log10(FS))

# Define Factors and Conditions
rt_exp_format <- rt_exp |>
  separate(targ_type, into = c("trial_type", "family_size", "complexity"), sep = "_",
           remove = TRUE, extra = "drop", fill = "right")

# Divide into Words and Nonwords
rt_words <- rt_exp_format |> filter(trial_type == "CW") |> select(- complexity)
rt_nwords <- rt_exp_format |> filter(trial_type == "NW")

# Join Stimulus Frequency Data
rt_words_frq <- left_join(rt_words, frq_w, join_by(target))|>
  select(-cond_trig.y, -word_trig.y) |>
  rename(cond_trig = cond_trig.x, word_trig = word_trig.x)  # remove duplicate columns
rt_nwords_frq <-  left_join(rt_nwords, frq_nw, join_by(target==word)) |>
  select(-cond_trig.y, -word_trig.y) |>
  rename(cond_trig = cond_trig.x, word_trig = word_trig.x)

# Rename BF_Split and FS_Split columns
rt_words_frq <- rt_words_frq |> rename(Base_Frequency = BF_Split, Family_Size = FS_Split) # Rename BF_Split and FS_Split columns
rt_nwords_frq <- rt_nwords_frq |> rename(Base_Frequency = BF_Split, Family_Size = FS_Split)

# Recode factor levels
# rt_words_frq <- rt_words_frq |>
#   mutate(Base_Frequency = case_match(Base_Frequency, "Low" ~ "Low BF", "High" ~ "High BF"),
```

```
#          Family_Size = case_match(Family_Size, "Small" ~ "Small Family", "Large" ~ "Large Family"))
# rt_nwords_frq <- rt_nwords_frq |> mutate(Base_Frequency = case_match(Base_Frequency, "Low" ~ "Low BF", "High" ~ "High BF"),
#                                         Family_Size = case_match(Family_Size, "Small" ~ "Small Family", "Large" ~ "Large Family"))
#
# rt_words_frq$Orthographic_Sensitivity[rt_words_frq$Orthographic_Sensitivity == "Low"] <- "Low Sensitivity"
# rt_words_frq$Orthographic_Sensitivity[rt_words_frq$Orthographic_Sensitivity == "High"] <- "High Sensitivity"
```

# Word Data

Use `complete.cases()` to find which rows have missing data in the model-relevant variables:

```
# Specify only the variables used in the model
model_vars_w <- c("response_time",  "Log10BF","BF", "FS","Family_Size", "Base_Frequency", "Orthographic_Sensitivity","SubjID")

# Identify incomplete rows cohort 1
incomplete_cases_words <- rt_words_frq[!complete.cases(rt_words_frq[, model_vars_w]), ]
rt_words_cmpl <- rt_words_frq[complete.cases(rt_words_frq[, model_vars_w]), ]
# View them
# print(incomplete_cases_words)
```

```
# Standardize the predictors
rt_words_cmpl$Log10BF_std <- as.numeric(scale(rt_words_cmpl$Log10BF, center = TRUE, scale = TRUE))
rt_words_cmpl$FS_std <- as.numeric(scale(rt_words_cmpl$FS, center = TRUE, scale = TRUE))
rt_words_cmpl$Log10WF_std <- as.numeric(scale(rt_words_cmpl$Log10WF, center = TRUE, scale = TRUE))
rt_words_cmpl$Log10FS_std <- as.numeric(scale(rt_words_cmpl$Log10FS, center = TRUE, scale = TRUE))
rt_words_cmpl$Dim.2_std <- as.numeric(scale(rt_words_cmpl$Dim.2, center = TRUE, scale = TRUE))
```

## Anova

```
anova_model_words <- mixed(
  response_time ~ Base_Frequency * Family_Size * Orthographic_Sensitivity +
    (1 + Base_Frequency + Family_Size | SubjID) +
    (1 | STRING),
  data = rt_words_cmpl,
  method = "S")
anova_model_words
```

```
|| Mixed Model Anova Table (Type 3 tests, S-method)
||
|| Model: response_time ~ Base_Frequency * Family_Size * Orthographic_Sensitivity +
|| Model:     (1 + Base_Frequency + Family_Size | SubjID) + (1 | STRING)
|| Data: rt_words_cmpl
||                                              Effect         df        F p.value
|| 1                                     Base_Frequency   1, 93.89 10.21 **    .002
|| 2                                        Family_Size   1, 92.33  9.05 **    .003
|| 3                            Orthographic_Sensitivity   1, 64.87   3.83 +    .055
|| 4                       Base_Frequency:Family_Size   1, 92.37     1.07    .303
|| 5            Base_Frequency:Orthographic_Sensitivity  1, 275.38     0.06    .809
|| 6               Family_Size:Orthographic_Sensitivity   1, 77.43     0.05    .822
|| 7 Base_Frequency:Family_Size:Orthographic_Sensitivity 1, 5627.69     0.16    .688
|| ---
|| Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '+' 0.1 ' ' 1
```

```
m1 <- anova_model_words$full_model    # Extract the lmer model
ranova(m1) # formally test whether adding each random effect improves fit
```

```
|| ANOVA-like table for random-effects: Single term deletions
||
|| Model:
|| response_time ~ Base_Frequency + Family_Size + Orthographic_Sensitivity + (1 + Base_Frequency + Family_Size | SubjID) + (1 | STRING) + Base_Fre
||                                                        npar logLik   AIC     LRT Df Pr(>Chisq)
|| <none>                                                   16 -35807 71646
|| Base_Frequency in (1 + Base_Frequency + Family_Size | SubjID)   13 -35809 71643   3.502  3     0.3205
|| Family_Size in (1 + Base_Frequency + Family_Size | SubjID)      13 -35807 71641   1.107  3     0.7753
|| (1 | STRING)                                                   15 -35897 71824 180.251  1     <2e-16 ***
|| ---
|| Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Extract effect sizes from your ANOVA model
eta_squared(anova_model_words, partial = TRUE)
```

```
|| # Effect Size for ANOVA (Type III)
||
|| Parameter                                    | Eta2 (partial) |       95% CI
|| -------------------------------------------------------------------------------
|| Base_Frequency                               |           0.10 | [0.02, 1.00]
|| Family_Size                                  |           0.09 | [0.02, 1.00]
|| Orthographic_Sensitivity                     |           0.06 | [0.00, 1.00]
|| Base_Frequency:Family_Size                   |           0.01 | [0.00, 1.00]
```

```
|| Base_Frequency:Orthographic_Sensitivity             |       2.12e-04 | [0.00, 1.00]
|| Family_Size:Orthographic_Sensitivity                |       6.57e-04 | [0.00, 1.00]
|| Base_Frequency:Family_Size:Orthographic_Sensitivity |       2.87e-05 | [0.00, 1.00]
||
|| - One-sided CIs: upper bound fixed at [1.00].
```

```
# Compute Marginal(fixed effects only) and Conditional(fixed + random effects) R²
r2(m1)
```

```
|| # R2 for Mixed Models
||
||   Conditional R2: 0.362
||      Marginal R2: 0.028
```

## Main Effects

| Effect | df | F | p.value |
|---|---|---|---|
| Base_Frequency | 1, 93.84 | 10.22 ** | .002 |
| Family_Size | 1, 92.69 | 9.12 ** | .003 |

```
emmeans(anova_model_words, ~ Family_Size)
```

## Means

```
||  Family_Size emmean   SE  df asymp.LCL asymp.UCL
||  Large          603 9.85 Inf       584       622
||  Small          622 9.88 Inf       602       641
||
|| Results are averaged over the levels of: Base_Frequency, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

```
emmeans(anova_model_words, ~ Base_Frequency)
```

```
||  Base_Frequency emmean    SE  df asymp.LCL asymp.UCL
||  High              602  9.62 Inf       584       621
||  Low               622 10.10 Inf       602       642
||
|| Results are averaged over the levels of: Family_Size, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

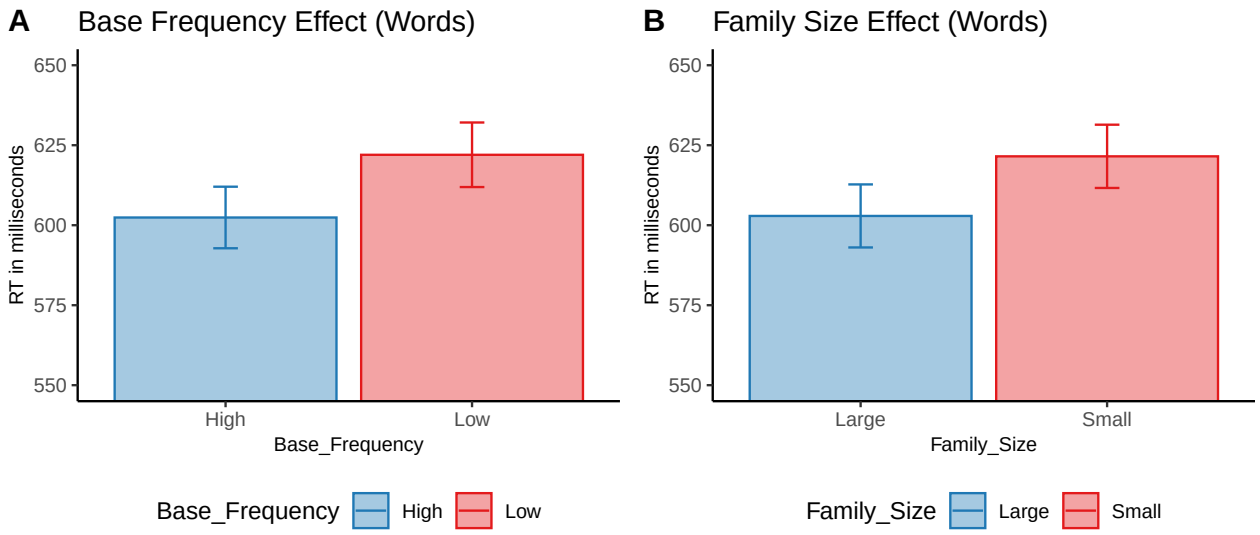
```
emmeans(anova_model_words, ~ Orthographic_Sensitivity)
```

```
||  Orthographic_Sensitivity emmean   SE  df asymp.LCL asymp.UCL
||  High                        595 12.5 Inf       570       619
||  Low                         630 13.4 Inf       603       656
||
|| Results are averaged over the levels of: Base_Frequency, Family_Size
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

## Plots

```
||  Base_Frequency   emmean        SE  df asymp.LCL asymp.UCL
||  High           602.4119  9.620811 Inf  583.5555  621.2684
||  Low            622.0116 10.090650 Inf  602.2343  641.7889
||
|| Results are averaged over the levels of: Family_Size, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

```
||  Family_Size   emmean       SE  df asymp.LCL asymp.UCL
||  Large       602.8992 9.849618 Inf  583.5943  622.2041
||  Small       621.5243 9.884542 Inf  602.1509  640.8976
||
|| Results are averaged over the levels of: Base_Frequency, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```


A
Base Frequency Effect (Words)
650
625
600
575
550
RT in milliseconds
High
Low
Base_Frequency
Base_Frequency
High
Low
B
Family Size Effect (Words)
650
625
600
575
550
RT in milliseconds
Large
Small
Family_Size
Family_Size
Large
Small

# Non-word Data

Use `complete.cases()` to find which rows had missing data in the model-relevant variables:

```
### Standardize the predictors

rt_nwords_cmpl$LogBF_std <- as.numeric(scale(rt_nwords_cmpl$LogBF, center = TRUE, scale = TRUE))
rt_nwords_cmpl$FS_std <- as.numeric(scale(rt_nwords_cmpl$FS, center = TRUE, scale = TRUE))
rt_nwords_cmpl$BF_std <- as.numeric(scale(rt_nwords_cmpl$BF, center = TRUE, scale = TRUE))
rt_nwords_cmpl$Dim.2_std <- as.numeric(scale(rt_nwords_cmpl$Dim.2, center = TRUE, scale = TRUE))
```

## Anova Family Size

```
anova_model_nwords_fs <- mixed(
  response_time ~ Complexity * Family_Size * Orthographic_Sensitivity +
    (1 + Complexity + Family_Size | SubjID) +
    (1 | ItemID),
  data = rt_nwords_cmpl,
  method = "S")
anova_model_nwords_fs
```

```
|| Mixed Model Anova Table (Type 3 tests, S-method)
||
|| Model: response_time ~ Complexity * Family_Size * Orthographic_Sensitivity +
|| Model:     (1 + Complexity + Family_Size | SubjID) + (1 | ItemID)
|| Data: rt_nwords_cmpl
||                                         Effect         df         F p.value
|| 1                                     Complexity   1, 62.51 91.00 ***   <.001
|| 2                                    Family_Size   1, 95.24      1.03    .313
|| 3                        Orthographic_Sensitivity   1, 63.54    5.33 *    .024
|| 4                          Complexity:Family_Size 1, 4476.13      0.90    .344
|| 5             Complexity:Orthographic_Sensitivity   1, 61.26      0.56    .457
|| 6           Family_Size:Orthographic_Sensitivity   1, 68.20      0.04    .839
|| 7 Complexity:Family_Size:Orthographic_Sensitivity 1, 4458.87      0.07    .787
|| ---
|| Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '+' 0.1 ' ' 1
```

```
m2 <- anova_model_nwords_fs$full_model    # Extract the lmer model
ranova(m2) # Run random effects comparison
```

```
|| ANOVA-like table for random-effects: Single term deletions
||
|| Model:
|| response_time ~ Complexity + Family_Size + Orthographic_Sensitivity + (1 + Complexity + Family_Size | SubjID) + (1 | ItemID) + Complexity:Famil
||                                                    npar logLik   AIC     LRT Df Pr(>Chisq)
|| <none>                                               16 -28031 56093
|| Complexity in (1 + Complexity + Family_Size | SubjID)    13 -28032 56090   3.056  3     0.3831
|| Family_Size in (1 + Complexity + Family_Size | SubjID)   13 -28032 56090   2.241  3     0.5239
|| (1 | ItemID)                                             15 -28103 56236 144.393  1     <2e-16 ***
|| ---
|| Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Extract effect sizes from your ANOVA model
eta_squared(anova_model_nwords_fs, partial = TRUE)
```

```
|| # Effect Size for ANOVA (Type III)
||
|| Parameter                                 | Eta2 (partial) |       95% CI
|| ------------------------------------------------------------------------------
|| Complexity                                |           0.59 | [0.46, 1.00]
|| Family_Size                               |           0.01 | [0.00, 1.00]
|| Orthographic_Sensitivity                  |           0.08 | [0.01, 1.00]
|| Complexity:Family_Size                    |       2.00e-04 | [0.00, 1.00]
|| Complexity:Orthographic_Sensitivity       |       9.08e-03 | [0.00, 1.00]
|| Family_Size:Orthographic_Sensitivity      |       6.12e-04 | [0.00, 1.00]
|| Complexity:Family_Size:Orthographic_Sensitivity |       1.64e-05 | [0.00, 1.00]
||
|| - One-sided CIs: upper bound fixed at [1.00].
```

```
# Compute Marginal(fixed effects only) and Conditional(fixed + random effects) R²
r2(anova_model_nwords_fs)
```

```
|| # R2 for Mixed Models
||
||   Conditional R2: 0.461
||      Marginal R2: 0.045
```

### Main Effects

| Effect | df | F | p.value |
|---|---|---|---|
| Complexity | 1, 61.93 | 89.98 *** | <.001 |
| Orthographic_Sensitivity | 1, 63.58 | 5.33 * | .024 |

```
emmeans(anova_model_nwords_fs, ~ Complexity)
```

## Main Effects Means

```
||  Complexity emmean   SE  df asymp.LCL asymp.UCL
||  Complex       736 11.1 Inf       715       758
||  Simple        701 10.9 Inf       680       723
||
|| Results are averaged over the levels of: Family_Size, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

```
emmeans(anova_model_nwords_fs, ~ Family_Size)
```

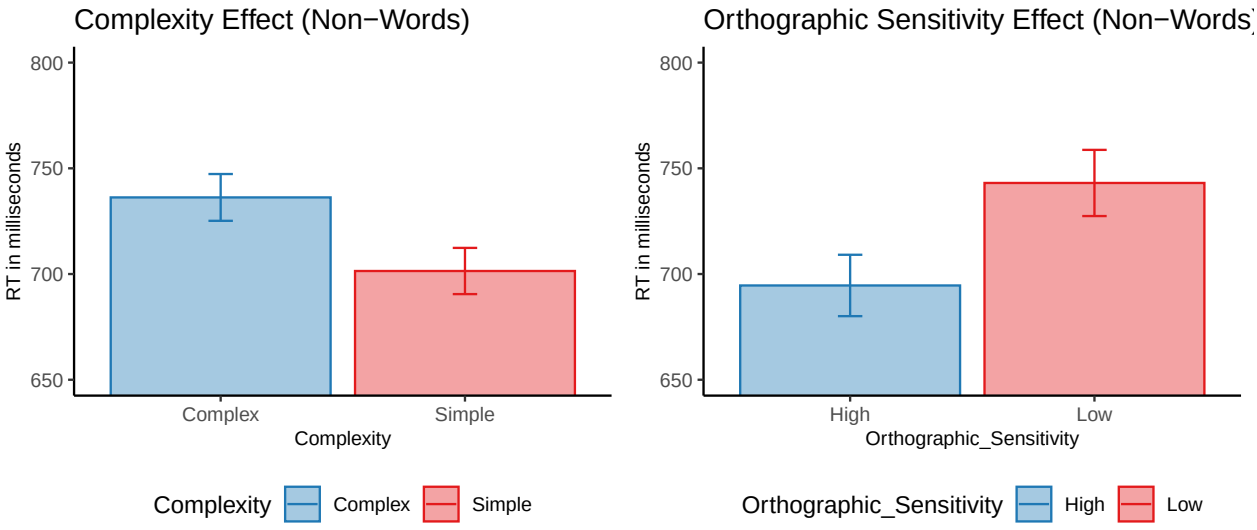
```
||  Family_Size emmean   SE  df asymp.LCL asymp.UCL
||  Large          722 11.2 Inf       700       744
||  Small          716 11.4 Inf       693       738
||
|| Results are averaged over the levels of: Complexity, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

```
emmeans(anova_model_nwords_fs, ~ Orthographic_Sensitivity)
```

```
||  Orthographic_Sensitivity emmean   SE  df asymp.LCL asymp.UCL
||  High                        695 14.5 Inf       666       723
||  Low                         743 15.7 Inf       712       774
||
|| Results are averaged over the levels of: Complexity, Family_Size
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

**Non-word complexity** had a robust effect; complex non-words (e.g., pseudoderived forms) elicited longer response times than simple ones. Participants with higher **orthographic sensitivity** responded significantly faster overall, suggesting more efficient processing of letter patterns even in non-words. **Morphological family size** did not modulate non-word RTs, nor did it interact with complexity or orthographic sensitivity. Interpretation: In the absence of lexical representations, apparent "family size" (based on real-word analogues) does not measurably influence non-word recognition.

## Main Effects Plots ...



## Anova Base Frequency

```
anova_model_nwords_bf <- mixed(
  response_time ~ Complexity * Base_Frequency * Orthographic_Sensitivity +
    (1 + Base_Frequency + Complexity | SubjID) +
    (1 | ItemID),
  data = rt_nwords_cmpl,
  method = "S")
anova_model_nwords_bf
```

```
|| Mixed Model Anova Table (Type 3 tests, S-method)
||
|| Model: response_time ~ Complexity * Base_Frequency * Orthographic_Sensitivity +
|| Model:     (1 + Base_Frequency + Complexity | SubjID) + (1 | ItemID)
|| Data: rt_nwords_cmpl
||                                             Effect         df         F p.value
|| 1                                        Complexity   1, 62.46 93.48 ***   <.001
|| 2                                   Base_Frequency   1, 91.60 11.72 ***   <.001
|| 3                          Orthographic_Sensitivity   1, 63.49    5.27 *    .025
|| 4                         Complexity:Base_Frequency 1, 4492.31    3.84 +    .050
|| 5               Complexity:Orthographic_Sensitivity   1, 61.11      0.39    .534
|| 6          Base_Frequency:Orthographic_Sensitivity   1, 68.70      0.19    .667
|| 7 Complexity:Base_Frequency:Orthographic_Sensitivity 1, 4466.11      0.41    .520
|| ---
|| Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '+' 0.1 ' ' 1
```

```
m3 <- anova_model_nwords_bf$full_model    # Extract the lmer model
ranova(m3) # Run random effects comparison
```

```
|| ANOVA-like table for random-effects: Single term deletions
||
|| Model:
|| response_time ~ Complexity + Base_Frequency + Orthographic_Sensitivity + (1 + Base_Frequency + Complexity | SubjID) + (1 | ItemID) + Complexity
||                                                       npar logLik   AIC     LRT Df Pr(>Chisq)
|| <none>                                                  16 -28023 56078
|| Base_Frequency in (1 + Base_Frequency + Complexity | SubjID)   13 -28024 56075   3.314  3     0.3458
|| Complexity in (1 + Base_Frequency + Complexity | SubjID)       13 -28024 56075   3.309  3     0.3463
|| (1 | ItemID)                                                  15 -28084 56199 123.189  1     <2e-16 ***
|| ---
|| Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Extract effect sizes from your ANOVA model
eta_squared(anova_model_nwords_bf, partial = TRUE)
```

```
|| # Effect Size for ANOVA (Type III)
||
|| Parameter                                          | Eta2 (partial) |       95% CI
|| ---------------------------------------------------------------------------------------
|| Complexity                                         |           0.60 | [0.47, 1.00]
|| Base_Frequency                                     |           0.11 | [0.03, 1.00]
|| Orthographic_Sensitivity                           |           0.08 | [0.01, 1.00]
|| Complexity:Base_Frequency                          |       8.54e-04 | [0.00, 1.00]
|| Complexity:Orthographic_Sensitivity                |       6.35e-03 | [0.00, 1.00]
|| Base_Frequency:Orthographic_Sensitivity            |       2.70e-03 | [0.00, 1.00]
|| Complexity:Base_Frequency:Orthographic_Sensitivity |       9.28e-05 | [0.00, 1.00]
||
|| - One-sided CIs: upper bound fixed at [1.00].
```

```
# Compute Marginal(fixed effects only) and Conditional(fixed + random effects) R²
r2(anova_model_nwords_bf)
```

```
|| # R2 for Mixed Models
||
||   Conditional R2: 0.461
||      Marginal R2: 0.050
```

## Main Findings

| Effect | df | F | p.value |
|---|---|---|---|
| Complexity | 1, 60.94 | 90.90 *** | <.001 |
| Base_Frequency | 1, 93.14 | 11.47 ** | <.001 |
| Orthographic_Sensitivity | 1, 63.60 | 5.24 * | .025 |
| Complexity:Base_Frequency | 1, 425.13 | 3.40 | .066 |

- Complexity: complex > simple non-words → slower responses.
- Base Frequency (: non-words derived from high-frequency bases were processed faster than those from low-frequency bases — an echo of lexical familiarity effects even though the items are illegal.
- Orthographic Sensitivity : same direction as before.

- Complexity × Base Frequency (marginal effect): The effect of complexity was larger for high-frequency bases than for low-frequency ones.

```
emmeans(anova_model_nwords_bf, ~ Complexity)
```

```
||  Complexity emmean   SE  df asymp.LCL asymp.UCL
||  Complex       736 11.1 Inf       715       758
||  Simple        701 10.9 Inf       680       722
||
|| Results are averaged over the levels of: Base_Frequency, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

```
emmeans(anova_model_nwords_bf, ~ Base_Frequency)
```

```
||  Base_Frequency emmean   SE  df asymp.LCL asymp.UCL
||  High              729 10.9 Inf       708       751
||  Low               708 11.5 Inf       686       731
||
|| Results are averaged over the levels of: Complexity, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

```
emmeans(anova_model_nwords_bf, ~ Orthographic_Sensitivity)
```

```
||  Orthographic_Sensitivity emmean   SE  df asymp.LCL asymp.UCL
||  High                       695 14.5 Inf       666       723
||  Low                        743 15.6 Inf       712       774
||
|| Results are averaged over the levels of: Complexity, Base_Frequency
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

## Interaction Effects: `Complexity x Base_Frequency`

```
# Estimated marginal means for the family_size × base frequency interaction
(emm1 <- emmeans(anova_model_nwords_bf, ~ Complexity * Base_Frequency))
```

## Simple Contrasts

```
||  Complexity Base_Frequency emmean   SE  df asymp.LCL asymp.UCL
||  Complex    High              750 11.4 Inf       728       772
||  Simple     High              708 11.1 Inf       687       730
||  Complex    Low               723 11.8 Inf       700       746
||  Simple     Low               694 11.7 Inf       671       717
||
|| Results are averaged over the levels of: Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```

```
# Get all pairswise contrasts
emm1_contrasts <- contrast(emm1,  method = "pairwise", by = NULL, adjust = "none")
emm1_contrasts
```

```
||  contrast                  estimate   SE  df z.ratio p.value
||  Complex High - Simple High     41.5 5.02 Inf   8.257  <.0001
||  Complex High - Complex Low     27.0 7.07 Inf   3.820  0.0001
||  Complex High - Simple Low      56.1 7.28 Inf   7.707  <.0001
||  Simple High - Complex Low     -14.5 6.90 Inf  -2.098  0.0359
||  Simple High - Simple Low       14.6 6.63 Inf   2.203  0.0276
||  Complex Low - Simple Low       29.1 4.63 Inf   6.283  <.0001
||
|| Results are averaged over the levels of: Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
```

```
# Keep only the contrasts you want
# Simple effects of Complexity at each level of Base_Frequency
# Simple effects of Base_Frequency at each level of Complexity
keep <- c("Complex High - Simple High",
          "Complex Low - Simple Low",
          "Complex High - Complex Low",
          "Simple High - Simple Low")
(emm1_contrasts_filtered <- subset(emm1_contrasts, contrast %in% keep))
```

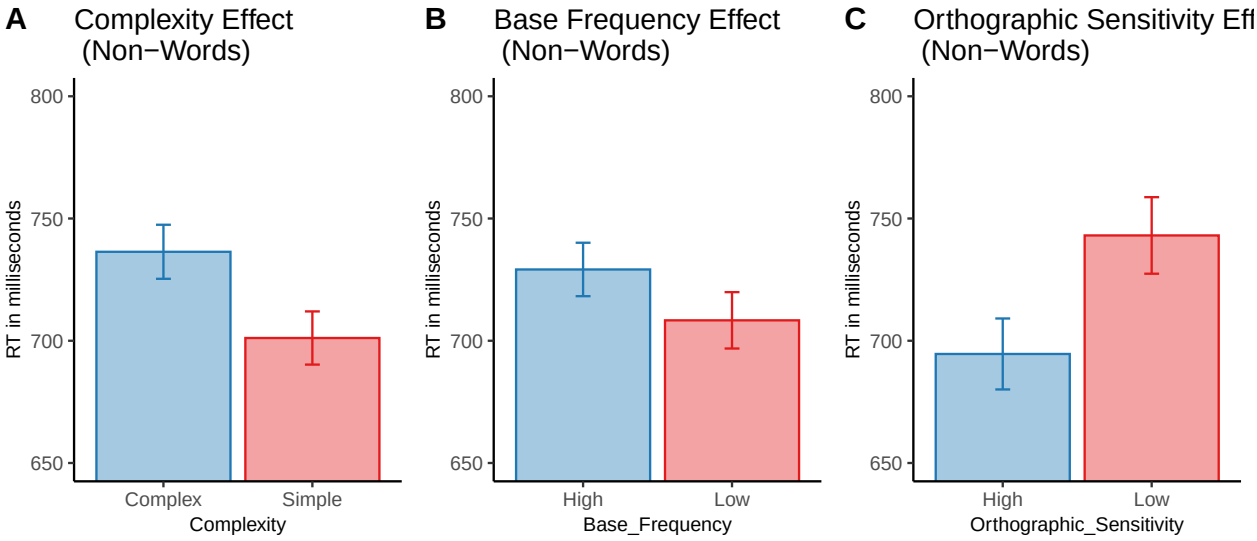
```
||  contrast                  estimate   SE  df z.ratio p.value
||  Complex High - Simple High     41.5 5.02 Inf   8.257  <.0001
||  Complex High - Complex Low     27.0 7.07 Inf   3.820  0.0001
||  Simple High - Simple Low       14.6 6.63 Inf   2.203  0.0276
||  Complex Low - Simple Low       29.1 4.63 Inf   6.283  <.0001
||
|| Results are averaged over the levels of: Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
```

## Main Effects Plots

```
||  Complexity   emmean       SE  df asymp.LCL asymp.UCL
||  Complex    736.3929 11.05749 Inf  714.7206  758.0652
||  Simple     701.1190 10.87627 Inf  679.8019  722.4361
||
|| Results are averaged over the levels of: Base_Frequency, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95

||  Base_Frequency   emmean       SE  df asymp.LCL asymp.UCL
||  High           729.1584 10.93142 Inf  707.7332  750.5836
||  Low            708.3535 11.52749 Inf  685.7601  730.9470
||
|| Results are averaged over the levels of: Complexity, Orthographic_Sensitivity
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95

||  Orthographic_Sensitivity   emmean       SE  df asymp.LCL asymp.UCL
||  High                     694.6257 14.50235 Inf  666.2016  723.0498
||  Low                      742.8862 15.64046 Inf  712.2315  773.5410
||
|| Results are averaged over the levels of: Complexity, Base_Frequency
|| Degrees-of-freedom method: asymptotic
|| Confidence level used: 0.95
```




## Interaction Plots