# STS

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## Analyses of stimuli

Checking for the differences in the sonority index i. French

```
##
##  Welch Two Sample t-test
##
## data:  FRE$sonority.index[FRE$sonority == "h"] and FRE$sonority.index[FRE$sonority == "l"]
## t = 8.0813, df = 9.9928, p-value = 1.082e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  1.219167 2.147500
## sample estimates:
## mean of x mean of y
##  5.616667  3.933333
```

ii. English

```
##
##  Welch Two Sample t-test
##
## data:  ENG$sonority.index[ENG$sonority == "h"] and ENG$sonority.index[ENG$sonority == "l"]
## t = 6.5909, df = 7.947, p-value = 0.0001762
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  1.137002 2.362998
## sample estimates:
## mean of x mean of y
##      6.05      4.30
```

```
##
##  Welch Two Sample t-test
##
## data:  FRE$sonority.index and ENG$sonority.index
## t = -1.0004, df = 21.889, p-value = 0.3281
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1.2294975  0.4294975
## sample estimates:
## mean of x mean of y
##     4.775     5.175
```

iii. French vs. English

```
##
##  Welch Two Sample t-test
##
## data:  FRE$sonority.index and ENG$sonority.index
## t = -1.0004, df = 21.889, p-value = 0.3281
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -1.2294975  0.4294975
## sample estimates:
## mean of x mean of y
##     4.775     5.175
```

Checking for the acoustic-phonetic correlate of the phonological sonority i. French

```
##
##  Welch Two Sample t-test
##
## data:  FRE$percent.sonorous[FRE$sonority == "h"] and FRE$percent.sonorous[FRE$sonority == "l"]
## t = 8.7821, df = 7.4833, p-value = 3.35e-05
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  29.71451 51.22596
## sample estimates:
## mean of x mean of y
##  79.64466  39.17442
```

ii. English

```
##
##  Welch Two Sample t-test
##
## data:  ENG$percent.sonorous[ENG$sonority == "h"] and ENG$percent.sonorous[ENG$sonority == "l"]
## t = 8.4847, df = 9.8408, p-value = 7.783e-06
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  28.32188 48.55449
## sample estimates:
## mean of x mean of y
##  84.87708  46.43890
```

iii. French vs. English

```
##
##  Welch Two Sample t-test
##
## data:  FRE$percent.sonorous and ENG$percent.sonorous
## t = -0.69732, df = 21.951, p-value = 0.4929
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -24.83419  12.33729
```

```
## sample estimates:
## mean of x mean of y
##  59.40954  65.65799
```

Checking for potential differences in speech rate i. French

```
##
##  Welch Two Sample t-test
##
## data:  FRE$speechrate[FRE$sonority == "h"] and FRE$speechrate[FRE$sonority == "l"]
## t = 1.194, df = 9.5132, p-value = 0.2614
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.5605327  1.8357583
## sample estimates:
## mean of x mean of y
##  5.543119  4.905506
```

ii. English

```
##
##  Welch Two Sample t-test
##
## data:  ENG$speechrate[ENG$sonority == "h"] and ENG$speechrate[ENG$sonority == "l"]
## t = 1.3391, df = 9.9778, p-value = 0.2102
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.4244235  1.7020606
## sample estimates:
## mean of x mean of y
##  5.186844  4.548026
```

iii. French vs. English

```
##
##  Welch Two Sample t-test
##
## data:  FRE$speechrate and ENG$speechrate
## t = 0.97114, df = 21.796, p-value = 0.3421
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.4056521  1.1194078
## sample estimates:
## mean of x mean of y
##  5.224313  4.867435
```

Checking for potential differences in pitch variability i. French

```
##
##  Welch Two Sample t-test
##
## data:  FRE$semitone[FRE$sonority == "h"] and FRE$semitone[FRE$sonority == "l"]
```

```
## t = -1.563, df = 84.223, p-value = 0.1218
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.63383659  0.07594669
## sample estimates:
## mean of x mean of y
## 0.1115998 0.3905447
```

ii. English

```
##
##  Welch Two Sample t-test
##
## data:  ENG$semitone[ENG$sonority == "h"] and ENG$semitone[ENG$sonority == "l"]
## t = -0.74736, df = 84.763, p-value = 0.4569
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.5484123  0.2487745
## sample estimates:
## mean of x mean of y
## 0.2442382 0.3940571
```

ii. French vs. English

```
##
##  Welch Two Sample t-test
##
## data:  FRE$semitone and ENG$semitone
## t = -0.47576, df = 170.82, p-value = 0.6349
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -0.3324781  0.2033361
## sample estimates:
## mean of x mean of y
## 0.2494691 0.3140402
```

## Preliminary analyses: Experiment-1

Wilcoxon signed-rank test based on mean ratings for all sentences at baseline vs. post repetition

```
##
##  Wilcoxon signed rank exact test
##
## data:  E1.baseline and E1.post.rep
## V = 0, p-value = 1.192e-07
## alternative hypothesis: true location shift is not equal to 0
```

## Preliminary analyses: Experiment-2

Wilcoxon signed-rank test based on mean ratings for all sentences at baseline vs. post repetition

```
## Warning in wilcox.test.default(E2.baseline, E2.post.rep, paired = TRUE): cannot
## compute exact p-value with ties
```

```
##
##  Wilcoxon signed rank test with continuity correction
##
## data:  E2.baseline and E2.post.rep
## V = 0, p-value = 9.556e-05
## alternative hypothesis: true location shift is not equal to 0
```

### Experiment-1

The likelihood of S2S, best-fit model

```
## Single term deletions
##
## Model:
## r.loop ~ sonority + n.syl + (1 | listener) + (1 | sentence)
##          npar    AIC    LRT  Pr(Chi)
## <none>        1059.6
## sonority    1 1065.0 7.4025 0.006513 **
## n.syl       1 1065.9 8.2969 0.003971 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula: r.loop ~ sonority + n.syl + (1 | listener) + (1 | sentence)
##    Data: E1
##
##      AIC      BIC   logLik deviance df.resid
##   1059.6   1083.9   -524.8   1049.6      954
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.3653 -0.5336 -0.1799  0.5837  4.3674
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  listener (Intercept) 2.8898   1.6999
##  sentence (Intercept) 0.7237   0.8507
## Number of obs: 959, groups:  listener, 80; sentence, 24
##
## Fixed effects:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  1.96416    0.67647   2.904  0.00369 **
## sonorityLow -1.14202    0.38688  -2.952  0.00316 **
## n.syl       -0.22526    0.07225  -3.118  0.00182 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Correlation of Fixed Effects:
##             (Intr) snrtyL
## sonorityLow -0.309
## n.syl       -0.870  0.031
```

The speed of S2S, best-fit model

```
## Single term deletions
##
## Model:
## r.cycle ~ sonority + n.syl + (1 | listener) + (1 | sentence)
##          Df    AIC     LRT  Pr(>Chi)
## <none>      1498.8
## sonority  1 1505.7  8.8995 0.0028524 **
## n.syl     1 1508.9 12.0889 0.0005072 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula: r.cycle ~ sonority + n.syl + (1 | listener) + (1 | sentence)
## data:    E1.subset1
##
##  link   threshold   nobs logLik  AIC     niter    max.grad cond.H
##  probit equidistant 420  -743.40 1498.80 320(963) 1.62e-04 5.0e+02
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  listener (Intercept) 0.5113   0.7150
##  sentence (Intercept) 0.0664   0.2577
## Number of groups:  listener 69,  sentence 24
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## sonorityLow  0.49298    0.15449   3.191 0.001418 **
## n.syl        0.11776    0.03125   3.768 0.000164 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##             Estimate Std. Error z value
## threshold.1  -1.0545     0.2781  -3.792
## spacing       0.7298     0.0320  22.804
```

The strength of S2S

```
## Single term deletions
##
## Model:
## r.post ~ sonority + n.syl + (1 | listener) + (1 | sentence)
##          Df    AIC    LRT  Pr(>Chi)
## <none>      3267.7
## sonority  1 3277.5 11.819 0.0005862 ***
```

```
## n.syl     1 3280.0 14.310 0.0001551 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula: r.post ~ sonority + n.syl + (1 | listener) + (1 | sentence)
## data:    E1.subset2
##
##  link   threshold   nobs logLik   AIC     niter     max.grad cond.H
##  probit equidistant 940  -1627.86 3267.72 310(1244) 2.38e-04 5.4e+02
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  listener (Intercept) 0.8885   0.9426
##  sentence (Intercept) 0.1627   0.4034
## Number of groups:  listener 80,  sentence 24
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## sonorityLow -0.70358    0.17958  -3.918 8.93e-05 ***
## n.syl       -0.14540    0.03344  -4.348 1.37e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##             Estimate Std. Error z value
## threshold.1 -2.80136    0.32681  -8.572
## spacing      0.64151    0.01905  33.675
```

### Experiment-2

The likelihood of S2S, best-fit model

```
## Single term deletions
##
## Model:
## r.loop ~ sonority + lang.stim + (1 | listener) + (1 | sentence)
##           npar    AIC     LRT   Pr(Chi)
## <none>         1608.1
## sonority     1 1611.2  5.0314   0.02489 *
## lang.stim    1 1628.5 22.3318 2.294e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula: r.loop ~ sonority + lang.stim + (1 | listener) + (1 | sentence)
##    Data: E2
##
##      AIC      BIC   logLik deviance df.resid
```

```
##   1608.1   1635.0   -799.1   1598.1     1595
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -6.3046 -0.4960 -0.1200  0.4978  5.0937
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  listener (Intercept) 4.0504   2.0126
##  sentence (Intercept) 0.9172   0.9577
## Number of obs: 1600, groups:  listener, 80; sentence, 20
##
## Fixed effects:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)   0.0300     0.3954   0.076   0.9395
## sonorityLow  -1.0746     0.4496  -2.390   0.0168 *
## lang.stimL2   0.6401     0.1341   4.775 1.79e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) snrtyL
## sonorityLow -0.564
## lang.stimL2 -0.163 -0.018
```

The speed of S2S, best-fit model

```
## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.
```

```
## Single term deletions
##
## Model:
## r.cycle ~ lang.stim + scale(L2.score) + (1 | listener) + (1 |
##     sentence)
##                 Df    AIC     LRT  Pr(>Chi)
## <none>             3002.4
## lang.stim        1 3017.4 17.0069 3.724e-05 ***
## scale(L2.score)  1 3006.6  6.1873   0.01287 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula: r.cycle ~ lang.stim + scale(L2.score) + (1 | listener) + (1 |
##     sentence)
## data:    E2.subset1
##
##  link   threshold   nobs logLik   AIC     niter     max.grad cond.H
##  probit equidistant 797  -1495.22 3002.43 358(1077) 9.91e-03 8.8e+01
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
```

```
##  listener (Intercept) 0.35270  0.5939
##  sentence (Intercept) 0.06397  0.2529
## Number of groups:  listener 74,  sentence 20
##
## Coefficients:
##                 Estimate Std. Error z value Pr(>|z|)
## lang.stimL2     -0.31362    0.07616  -4.118 3.82e-05 ***
## scale(L2.score)  0.20180    0.08053   2.506   0.0122 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##             Estimate Std. Error z value
## threshold.1 -2.38277    0.13298  -17.92
## spacing      0.63175    0.01869   33.81
```

The strength of S2S

```
## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.

## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.

## Single term deletions
##
## Model:
## r.post ~ sonority + lang.stim * scale(L2.score) + (1 | listener) +
##     (1 | sentence)
##                            Df    AIC    LRT Pr(>Chi)
## <none>                        5388.9
## sonority                    1 5390.8 3.9021 0.048225 *
## lang.stim:scale(L2.score)   1 5395.8 8.9039 0.002846 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Model summary for the reference level "L1"

```
## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.

## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula: r.post ~ sonority + lang.stim * scale(L2.score) + (1 | listener) +
##     (1 | sentence)
## data:    E2.subset2
##
##  link   threshold   nobs logLik   AIC     niter     max.grad cond.H
##  probit equidistant 1580 -2686.44 5388.88 525(2104) 9.63e-03 5.8e+02
```

```
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  listener (Intercept) 0.9988   0.9994
##  sentence (Intercept) 0.3428   0.5855
## Number of groups:  listener 80,  sentence 20
##
## Coefficients:
##                              Estimate Std. Error z value Pr(>|z|)
## sonorityLow                  -0.55522    0.26752  -2.075  0.03794 *
## lang.stimL2                   0.71550    0.05542  12.911  < 2e-16 ***
## scale(L2.score)               0.01408    0.12258   0.115  0.90858
## lang.stimL2:scale(L2.score) -0.24369    0.08190  -2.976  0.00292 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##             Estimate Std. Error z value
## threshold.1 -1.21775    0.22348  -5.449
## spacing      0.60932    0.01398  43.599
```

Model summary for the reference level "L2"

```
## Warning: Using formula(x) is deprecated when x is a character vector of length > 1.
##   Consider formula(paste(x, collapse = " ")) instead.

## Cumulative Link Mixed Model fitted with the Laplace approximation
##
## formula: r.post ~ sonority + lang.stim * scale(L2.score) + (1 | listener) +
##     (1 | sentence)
## data:    E2.subset2
##
##  link   threshold   nobs logLik   AIC     niter     max.grad cond.H
##  probit equidistant 1580 -2686.44 5388.88 495(1984) 1.41e-04 5.9e+02
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  listener (Intercept) 0.9988   0.9994
##  sentence (Intercept) 0.3428   0.5855
## Number of groups:  listener 80,  sentence 20
##
## Coefficients:
##                              Estimate Std. Error z value Pr(>|z|)
## sonorityLow                  -0.55522    0.26752  -2.075  0.03794 *
## lang.stimL1                  -0.71549    0.05542 -12.911  < 2e-16 ***
## scale(L2.score)              -0.22962    0.12233  -1.877  0.06051 .
## lang.stimL1:scale(L2.score)  0.24370    0.08190   2.976  0.00292 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold coefficients:
##             Estimate Std. Error z value
## threshold.1 -1.93324    0.22560  -8.569
## spacing      0.60932    0.01398  43.599
```