The effect of morphological boundaries on stem vowel duration in English

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Introduction

- Recent research has found that morphology and phonetic detail may interact
  - Phonetic detail may be sensitive to morphological information; morphemic word-final /s/ is shorter than monomorphemic /s/ (Plag, Homann & Kunter 2017)
  - Segments preceding morphemic final /s/ are shorter (Zimmermann 2018)
  - Stem duration of morphemic & non-morphemic words differ; *free#s* vs. *freeze* (Seyfarth et al 2017)

- First indications that English vowel duration may be dependent on presence or absence of a following word-internal morphemic boundary: *need* vs. *knee#d*

Theoretical Background: Vowel duration in English

- Vowels are longer before final voiced consonants than before final voiceless consonants (Klatt & Cooper 1975; Klatt 1976; Chen 1970; House & Fairbanks 1953)
- Some varieties have phonological rules that interact with morphological boundaries
  - Canadian Raising: doesn't take place before class II suffixes *(eyeful* vs. *Eiffel)* (Bermúdez-Otero 2006:391)
  - Scottish Vowel Length Rule: vowels are lengthened before /r/, voiced fricatives, and before morphological boundaries (e.g. *brewed* [bru:d] vs. *brood* [brud]) (McMahon 1991; Giegerich 1992)
- Morphological relatives of a word may influence that word's phonetic realisation (paradigm uniformity; *free* may influence *free#d*) (Seyfarth et al. 2017)

Research Question

- Is there an effect of the presence or absence of a morpheme boundary on the duration of the vowel preceding final /z/ and /d/? How can we interpret such an effect?
  - Vowel lengthening rule interacting with morphological information
  - Paradigm uniformity (i.e. longer vowel before morphemic boundaries; *free* influencing *free#d*)

Methodology

- Monosyllabic words that end in /t, d, s, z/ in phonological representation
- Buckeye Corpus (Pitt et al. 2007)
- English Lexicon Project (Balota et al. 2007)
  - Data was extracted using corpus query tool Coquery (Kunter 2017)
- Example words:
  - Simplex: /z, s/ *jazz, juice* /d, t/ *glad, neat*
  - Complex: /z/ *keys* /d/ *tried*

Variables

- Predictor:
  - Vowel duration in seconds
- Fixed effects:
  - Voicing of final consonant
  - Boundary type
  - Number of phonemes
  - Following pause after word
  - Word form frequency (in Buckeye Corpus)
- Random effects:
  - Vowel
  - Speaker (ID from Buckeye Corpus)

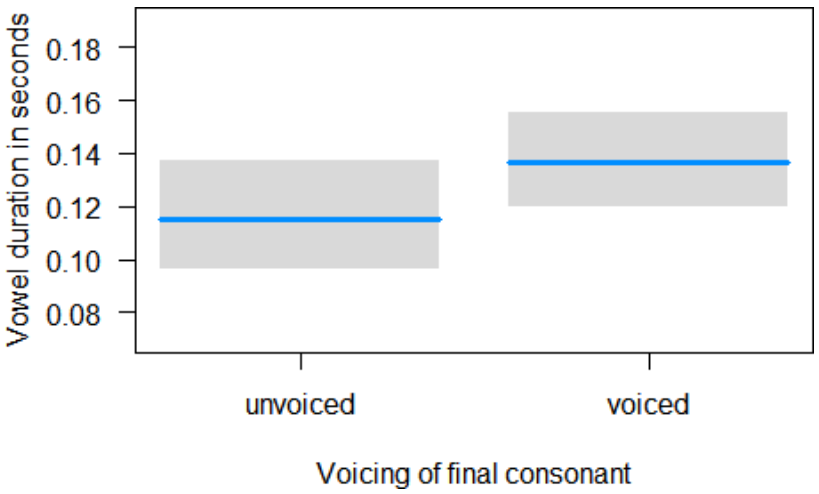
Statistical Analysis

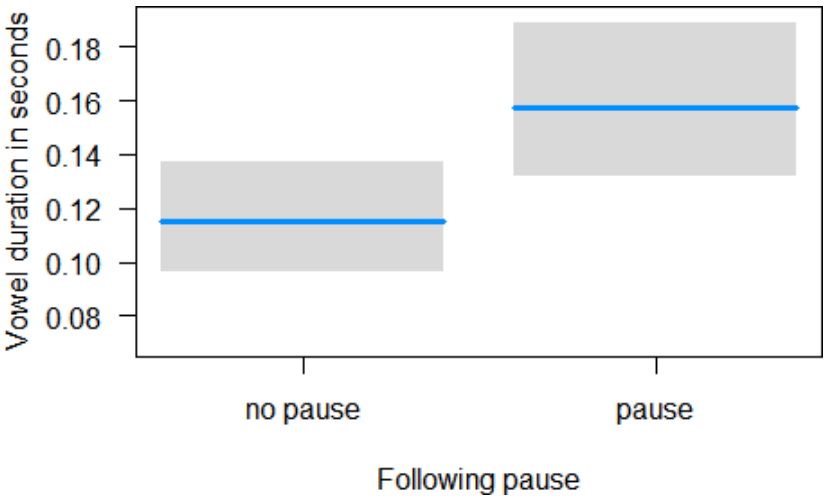
- Mixed effects regression model using R & lme4 (R Core Team 2015; Bates et al. 2017)
- Separate models for different subsets
  - simplex words: /s/ vs /z/, *N*=1554; e.g. *jazz, juice*
  - simplex words: /t/ vs /d/, *N*=4258; e.g *glad, neat*
  - complex vs. simplex words: /z/, *N*=548; e.g. *cruise, keys*
  - complex vs. simplex words: /d/, *N*=369; e.g. *trade, tried*

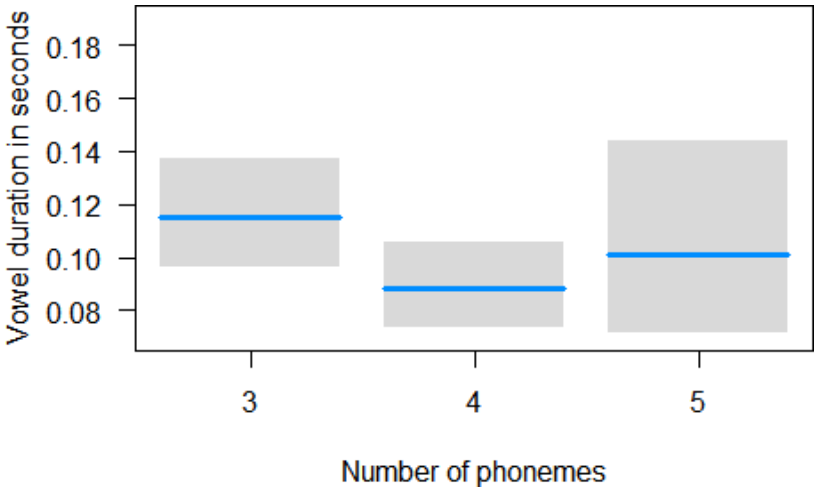
Statistical Analysis

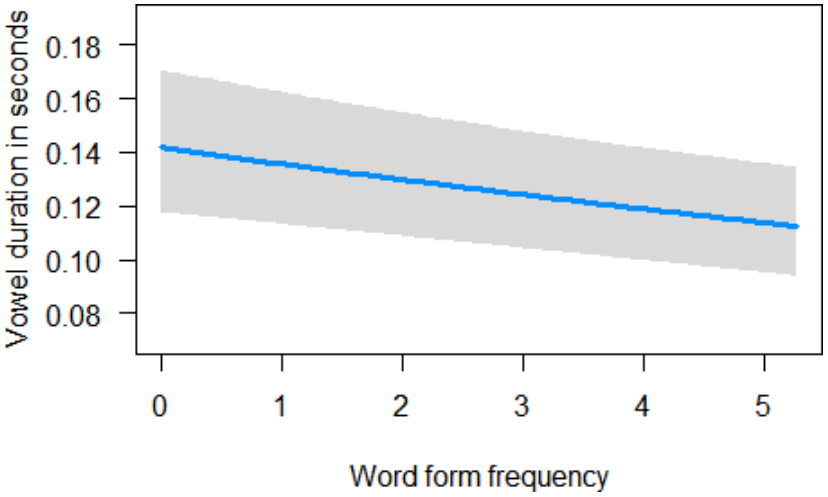
- Simplex words: Vowel lengthening effect
  - Vowel duration predicted by voicing of final consonant
  - Interaction between voicing of final consonant and following pause
- Complex vs. simplex words: Boundary effects
  - Boundary type
  - Interaction between boundary type and following pause
- Random effects for vowel & speaker
- No random effect for word due to distribution

Results: Simplex words ending in /z, s/

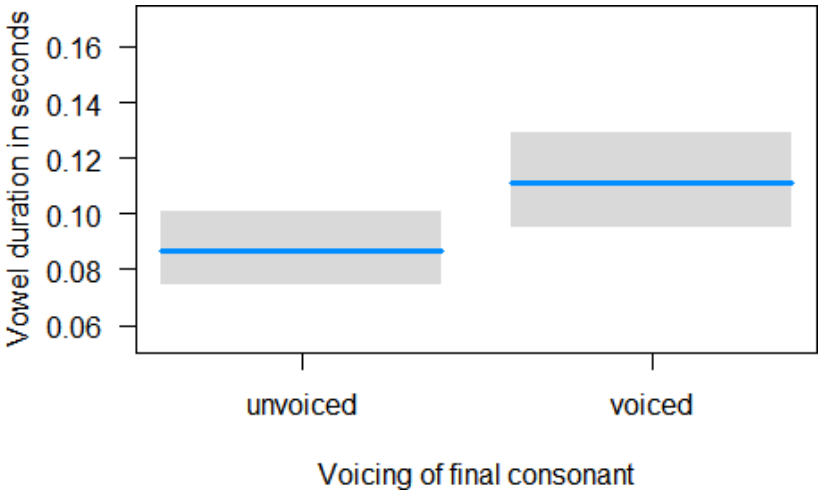


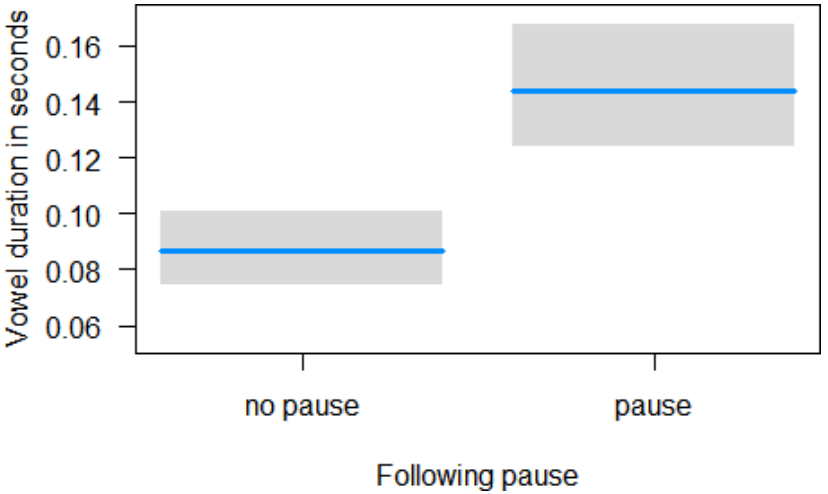


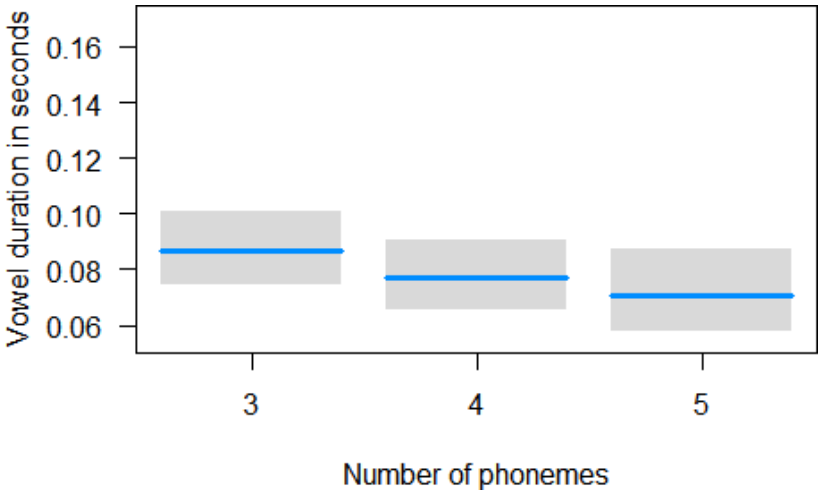


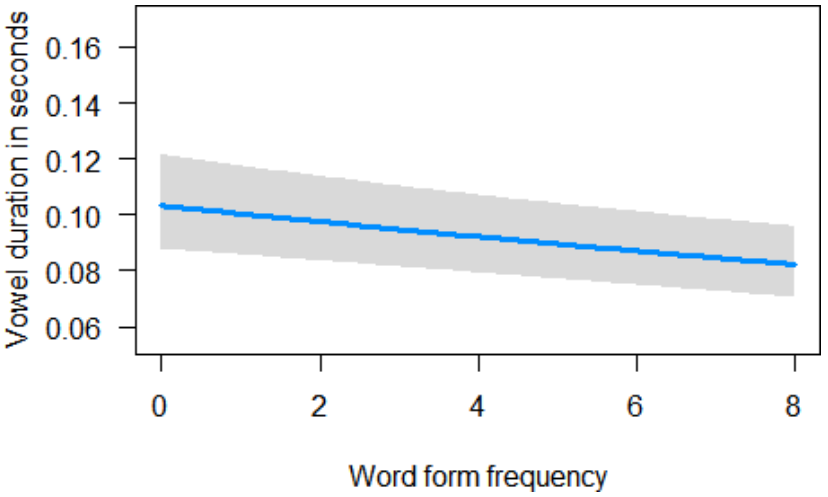


Results: Simplex words ending in /d, t/

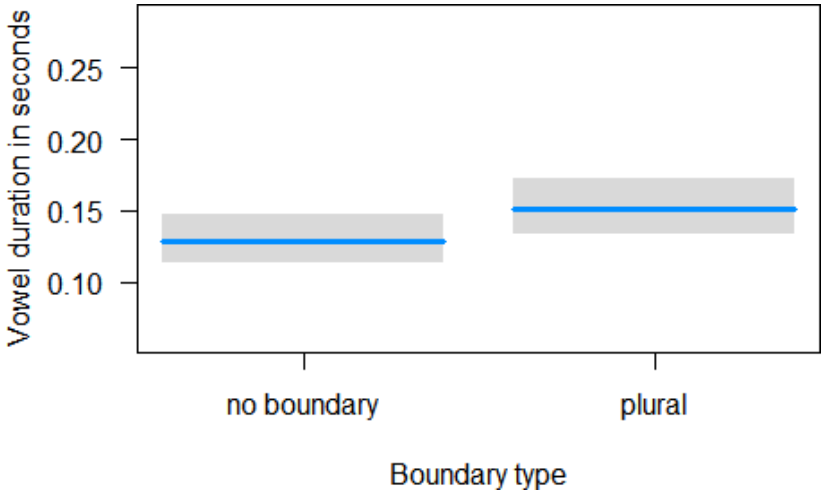


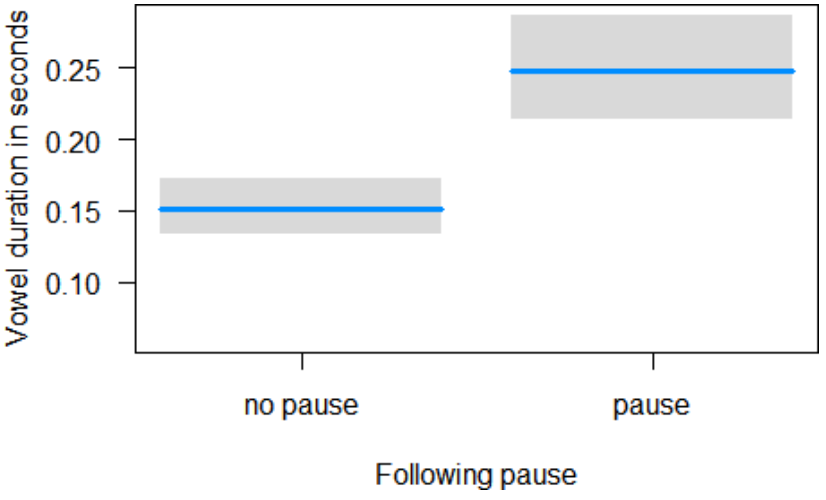


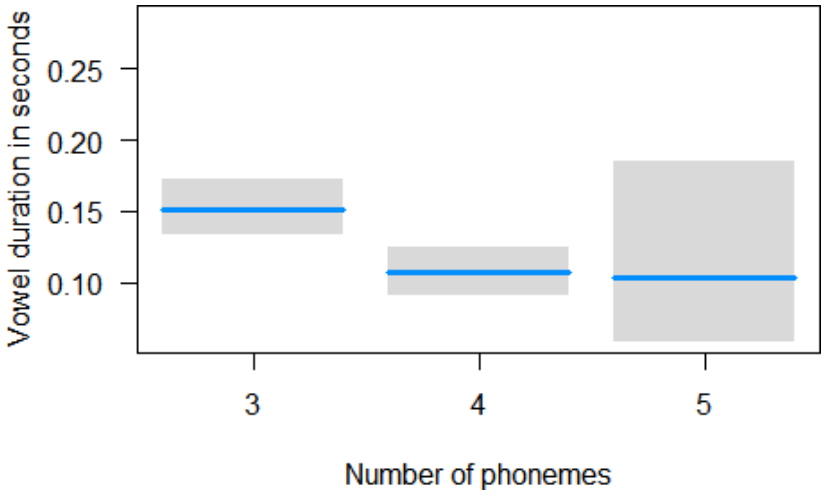


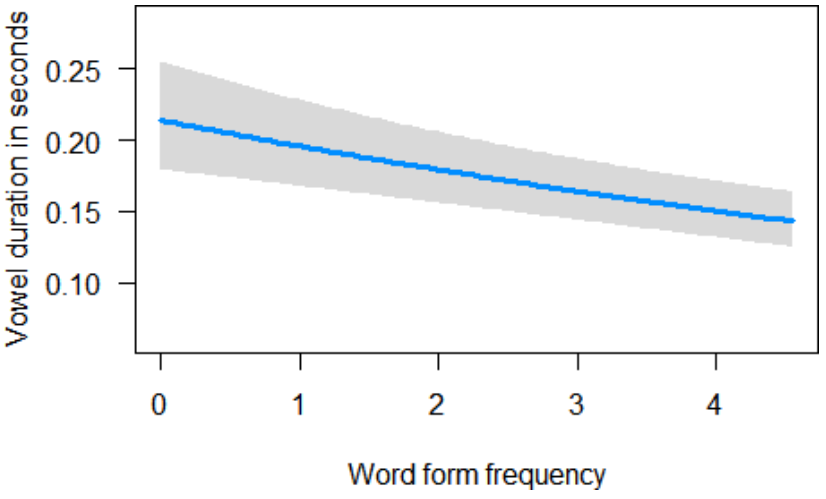


Results: Boundary effects for /z/

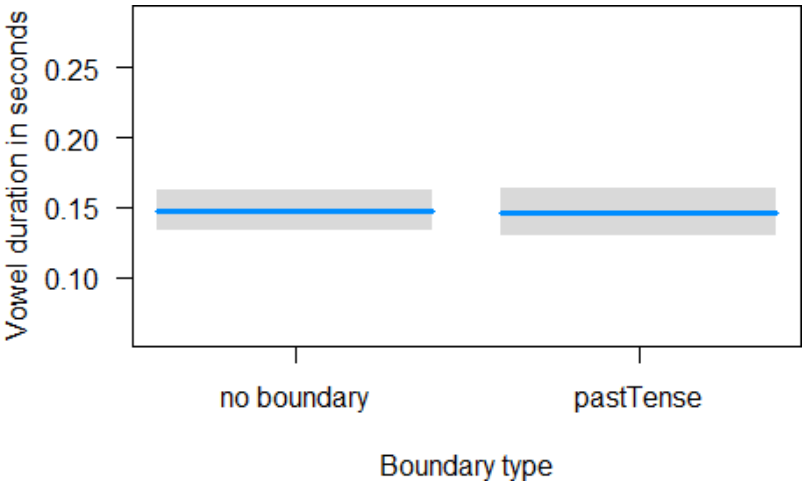


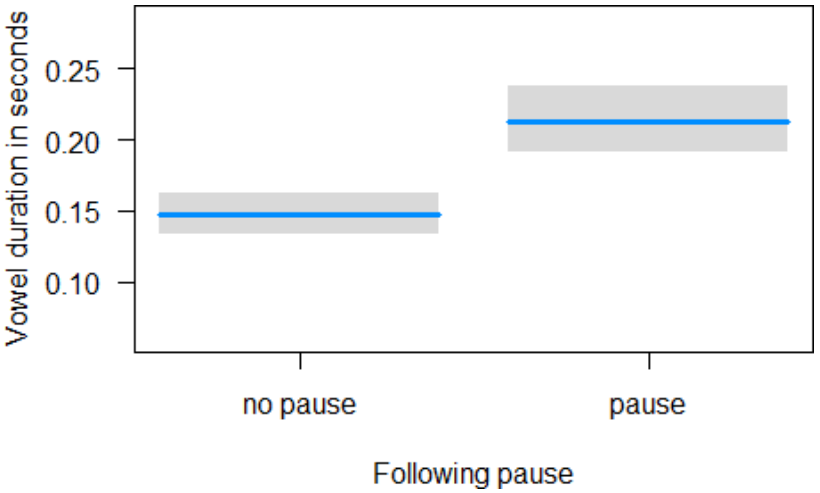


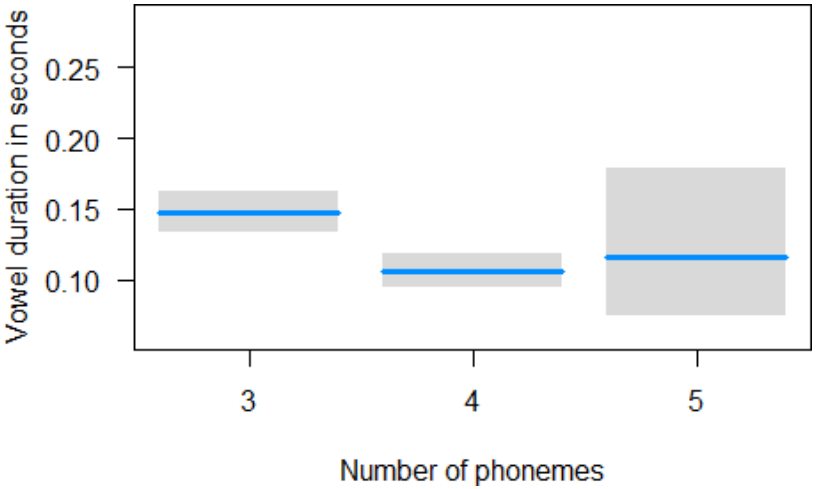


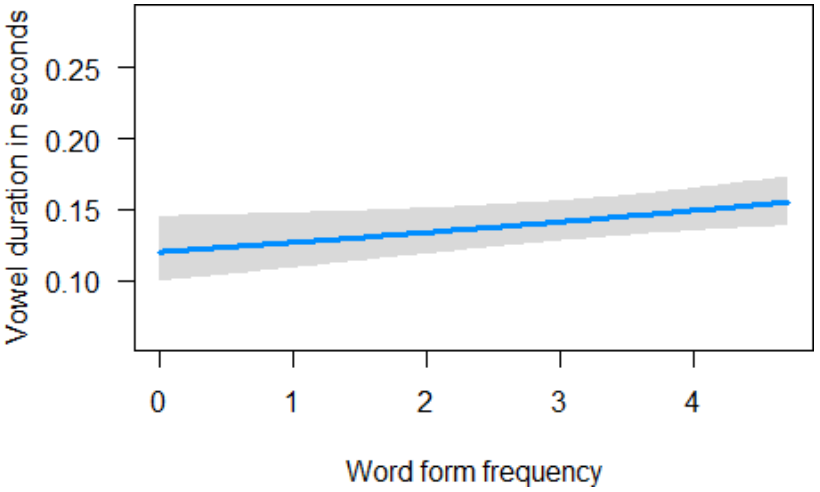


Results: Boundary effects for /d/









Results: Boundary effects

/z/

- Vowel before plural /z/ is longer (20 ms) than before non-morphemic /z/.

/d/

- No effect of past tense morphological boundary on preceding vowel
- Potentially counter-intuitive effect of word-form frequency

Research Question

- Is there an effect of the presence or absence of a morpheme boundary on the duration of the vowel preceding final /z/ and /d/? How can we interpret such an effect?

Discussion /z/

- There is an effect of the boundary on the preceding vowel
- Results are similar to Seyfarth et al. (2017):
  - They: 18 ms longer stems
  - We: 20 ms longer vowels
- Interpretation 1: Vowel lengthening effect is sensitive to morphological boundary
- Interpretation 2: Paradigm uniformity

Discussion /d/

- There is no effect of the boundary on the duration of the vowel
- Results are in line with Seyfarth et al. (2017)
- Interpretation unclear
- Small and potentially skewed sample for /d/: controlled experiments needed

Further research

/z/

- Test the difference between vowels and consonants preceding the boundary (e.g. *bee#s* vs. *bean#s*)
  - Paradigm uniformity predicts same effect
  - Morpho-phonological rule predicts a difference

/d/

- Try to understand the null effects, or find effects by doing more studies or experiments

Thank you for your attention!

References (1/2)

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Results: Simplex words ending in /z, s/

```
Linear mixed model fit by REML t-tests use Satterthwaite approximations to degrees of
freedom [lmerMod]
Formula: LogVowelLength ~ FinalConsVoicingUR + PauseFollows + NumPhonCat +
   LogFreqBuckeye + (1 + FinalConsVoicingUR | Vowel) + (1 | Speaker)
   Data: mmsF

REML criterion at convergence: 1359.6

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.5417 -0.6329  0.0057  0.6327  3.4071

Random effects:
 Groups   Name                        Variance Std.Dev. Corr
 Speaker  (Intercept)                 0.02743  0.1656
 Vowel    (Intercept)                 0.07872  0.2806
          FinalConsVoicingURvoiced    0.03215  0.1793   -0.88
 Residual                             0.12714  0.3566
Number of obs: 1554, groups:  Speaker, 40; Vowel, 12

Fixed effects:
                           Estimate Std. Error         df t value Pr(>|t|)
(Intercept)              -1.954e+00  9.489e-02  1.720e+01 -20.589 1.47e-13 ***
FinalConsVoicingURvoiced  1.715e-01  7.124e-02  9.200e+00   2.408   0.0389 *
PauseFollowspause         3.138e-01  2.158e-02  1.512e+03  14.540  < 2e-16 ***
NumPhonCat4              -2.675e-01  2.724e-02  1.233e+03  -9.818  < 2e-16 ***
NumPhonCat5              -1.276e-01  1.512e-01  1.504e+03  -0.843   0.3991
LogFreqBuckeye           -4.387e-02  9.949e-03  5.394e+02  -4.409 1.25e-05 ***
```

Results: Simplex words ending in /d, t/

```
Linear mixed model fit by REML t-tests use Satterthwaite approximations to degrees of
freedom [lmerMod]
Formula: LogVowelLength ~ FinalConsVoicingUR + PauseFollows + NumPhonCat +
    LogFreqBuckeye + (1 | Vowel) + (1 | Speaker)
    Data: mmtF

REML criterion at convergence: 5033.9

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.2126 -0.6213  0.0089  0.6149  3.7391

Random effects:
 Groups   Name        Variance Std.Dev.
 Speaker  (Intercept) 0.02040  0.1428
 Vowel    (Intercept) 0.06091  0.2468
 Residual             0.18325  0.4281
Number of obs: 4258, groups:  Speaker, 40; Vowel, 12

Fixed effects:
                           Estimate Std. Error         df t value Pr(>|t|)
(Intercept)              -2.270e+00  8.262e-02  1.900e+01 -27.478  < 2e-16 ***
FinalConsVoicingURvoiced  2.446e-01  2.045e-02  4.218e+03  11.960  < 2e-16 ***
PauseFollowspause         5.065e-01  1.549e-02  4.223e+03  32.693  < 2e-16 ***
NumPhonCat4              -1.172e-01  3.143e-02  4.219e+03  -3.730 0.000194 ***
NumPhonCat5              -2.042e-01  7.466e-02  4.221e+03  -2.735 0.006265 **
LogFreqBuckeye           -2.843e-02  6.122e-03  4.057e+03  -4.644 3.52e-06 ***
```

Results: Boundary effects for /z/

```
Linear mixed model fit by REML t-tests use Satterthwaite approximations to degrees of
freedom [lmerMod]
Formula: LogVowelLength ~ BoundaryType + PauseFollows + NumPhonCat + LogFreqBuckeye +
    (1 | Speaker) + (1 | Vowel)
    Data: monosylz

REML criterion at convergence: 599.9

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.8752 -0.6285  0.0085  0.6113  3.2385

Random effects:
 Groups   Name        Variance Std.Dev.
 Speaker  (Intercept) 0.02560  0.1600
 Vowel    (Intercept) 0.01325  0.1151
 Residual             0.15317  0.3914
Number of obs: 548, groups:  Speaker, 40; Vowel, 5

Fixed effects:
                   Estimate Std. Error        df t value Pr(>|t|)
(Intercept)        -1.70590    0.08923  26.20000 -19.117  < 2e-16 ***
BoundaryTypeplural  0.16316    0.04218 479.50000   3.868 0.000125 ***
PauseFollowspause   0.49022    0.04412 514.90000  11.111  < 2e-16 ***
NumPhonCat4        -0.35390    0.05756 377.20000  -6.149 1.99e-09 ***
NumPhonCat5        -0.38319    0.28949 511.60000  -1.324 0.186200
LogFreqBuckeye     -0.08829    0.01737 456.30000  -5.084 5.41e-07 ***
```

Results: Boundary effects for /d/

```
Linear mixed model fit by REML t-tests use Satterthwaite approximations to degrees of
freedom [lmerMod]
Formula: LogVowelLength ~ BoundaryType + LogFreqBuckeye + NumPhonCat +
    PauseFollows + (1 | Speaker) + (1 | Vowel)
    Data: monosyld

REML criterion at convergence: 347.2

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.8511 -0.6498 -0.0075  0.7038  2.5841

Random effects:
 Groups   Name        Variance Std.Dev.
 Speaker  (Intercept) 0.033935 0.18422
 Vowel    (Intercept) 0.001929 0.04393
 Residual             0.125116 0.35372
Number of obs: 369, groups:  Speaker, 40; Vowel, 4

Fixed effects:
                     Estimate Std. Error        df t value Pr(>|t|)
(Intercept)           -2.12016    0.09694 129.60000 -21.872  < 2e-16 ***
BoundaryTypepastTense -0.01030    0.04625 266.50000  -0.223   0.8240
LogFreqBuckeye         0.05432    0.02373 338.50000   2.289   0.0227 *
NumPhonCat4           -0.32554    0.04642 110.80000  -7.013 1.94e-10 ***
NumPhonCat5           -0.23950    0.21784 309.90000  -1.099   0.2724
PauseFollowspause      0.37026    0.04422 343.30000   8.372 1.33e-15 ***
```