THE ROLE OF PROSODIC ACCENTUATION ON VOWEL PRODUCTION IN ENGLISH

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OUTLINE

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2 Materials and method

3 Results

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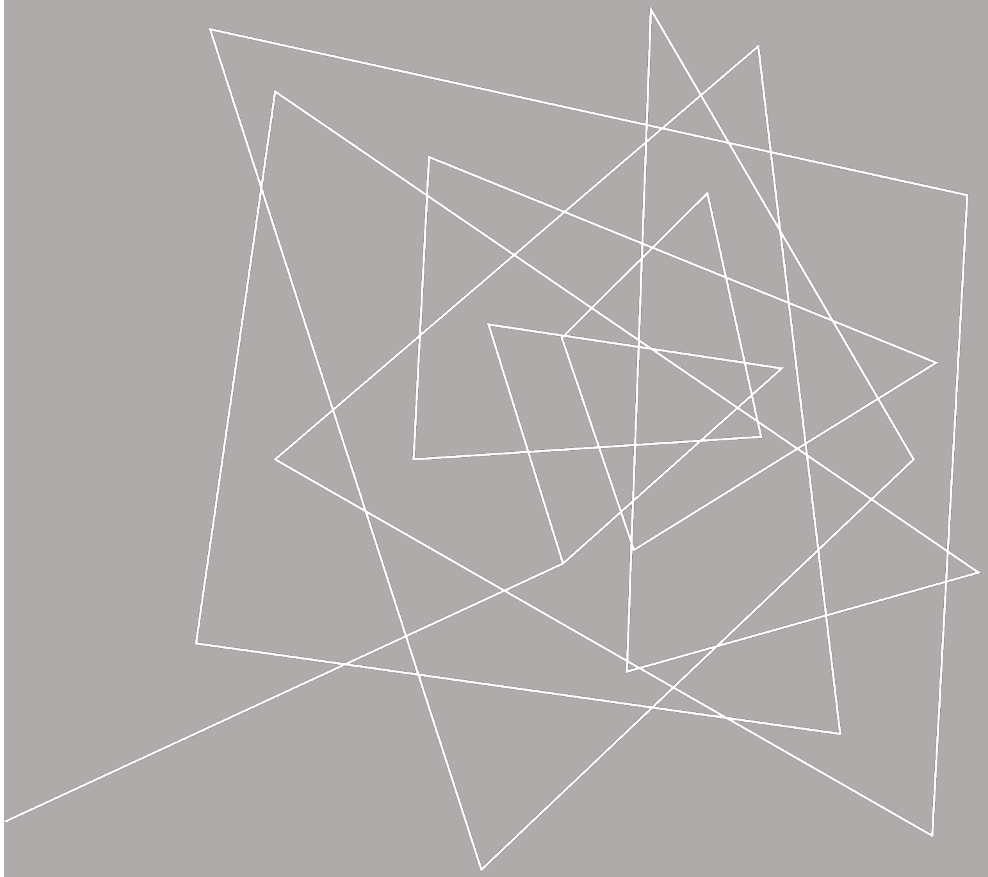


INTRODUCTION

INTRODUCTION

In previous research:

suprasegmental aspects of speech production affect the production of individual speech sounds (Fougeron & Keating 1997; Byrd 1996, 2000; Breen *et al.* 2010; Byrd & Choi 2010; Krivokapić 2014), e.g.:

- syllable structure (e.g. Browman & Goldstein 1988, 2000; Gafos & Goldstein 2012; Gibson *et al.* 2019; Hermes *et al.* 2012),

  e.g. less overlap between consonants in cluster in onset than in coda

- prosodic structure:
  - proximity to strong prosodic boundary
  - accentuation

INTRODUCTION

Prosodic strengthening of vowel:

- proximity to strong prosodic boundary (e.g. IU boundary), e.g.
  - domain-final lengthening (e.g. Edwards *et al.* 1991; Wightman *et al*. 1992)
  - domain-final vowels produced with greater articulatory magnitude → greater V-to-C displacement (e.g. Fougeron & Keating 1997; Cho 2002)
  - domain-initial strengthening, e.g. consonants in IU-initial position produced with more constriction than in middle of IU (e.g. Fougeron & Keating 1997; Cho & Keating 2009), greater intensity (Cho & Keating 2009)

INTRODUCTION

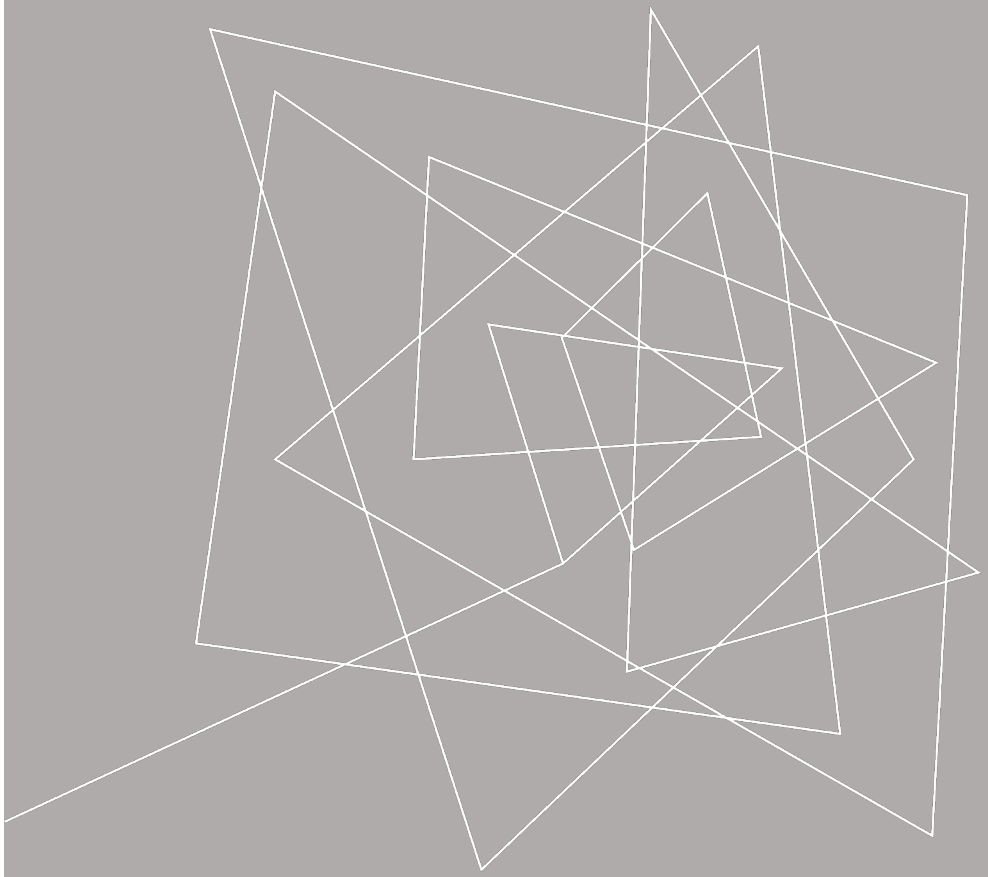
Prosodic strengthening of vowel:

– accentuation

INTRODUCTION

Two models of prosodic transcription

- ToBI (e.g. Pierrehumbert & Hirschberg 1990; Silverman *et al.* 1992)
- nuclear tone approach (e.g. Halliday 1967; Tench 1996)



MATERIALS AND METHOD

MATERIALS AND METHOD

London Lund Corpus of Spoken English:

- spontaneous conversations
- mostly educated Londoners (unaware of being recorded)
- audiomaterial and transcriptions (in nuclear tone approach)

MATERIALS AND METHOD

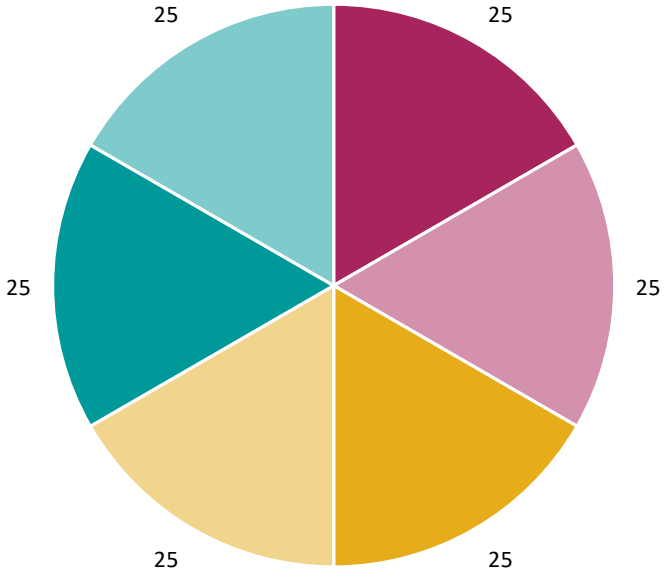
Sample of 150 vowels:

- checked monophthongs
- closed syllable with fortis coda (i.e. fortis fricative, plosive or affricate)
- monosyllabic words (↔ polysyllabic shortening)
- 29 speakers (mean utterance per speaker = 5.172414):
  - 13 female: mean utterance per speaker = 5
  - 16 male: mean utterance per speaker = 5.3125

MATERIALS AND METHOD

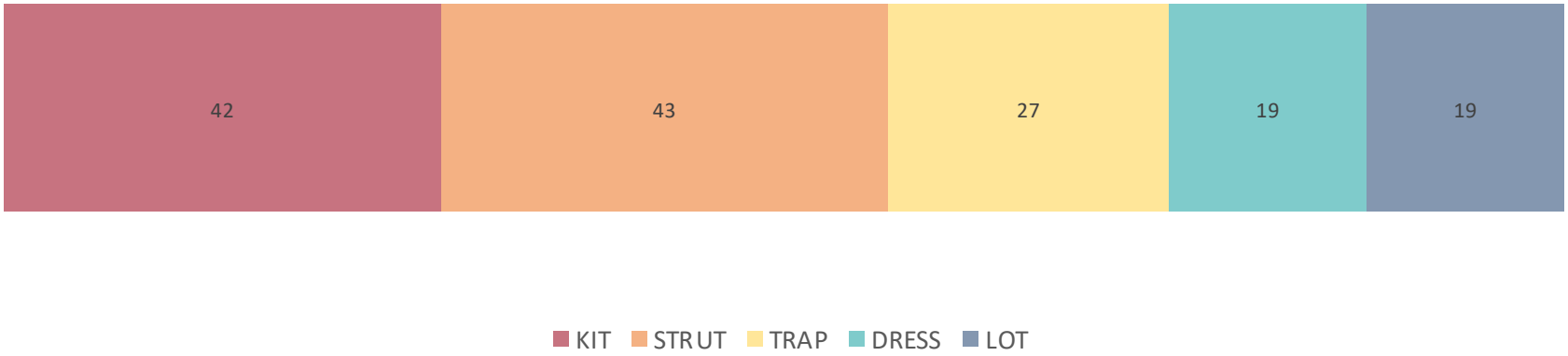
Sample of 150 vowels:

- equal distribution of **primary** accentuation (red), **secondary** accentuation (yellow) and **non-accentuation** (green)
- equal distribution (per accentuation status) of syllables preceding IU boundaries (light) and non-IU boundaries (dark)

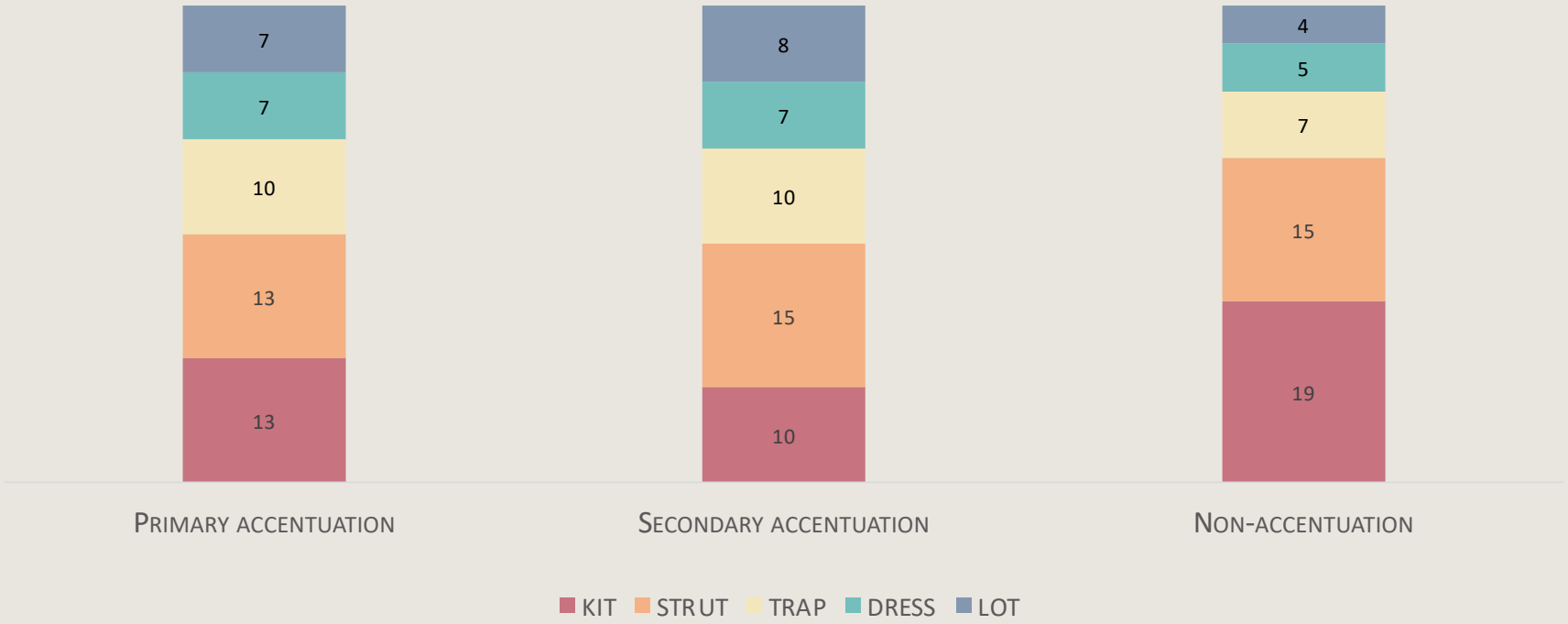


MATERIALS AND METHOD

Sample of 150 vowels: distribution of vowel types

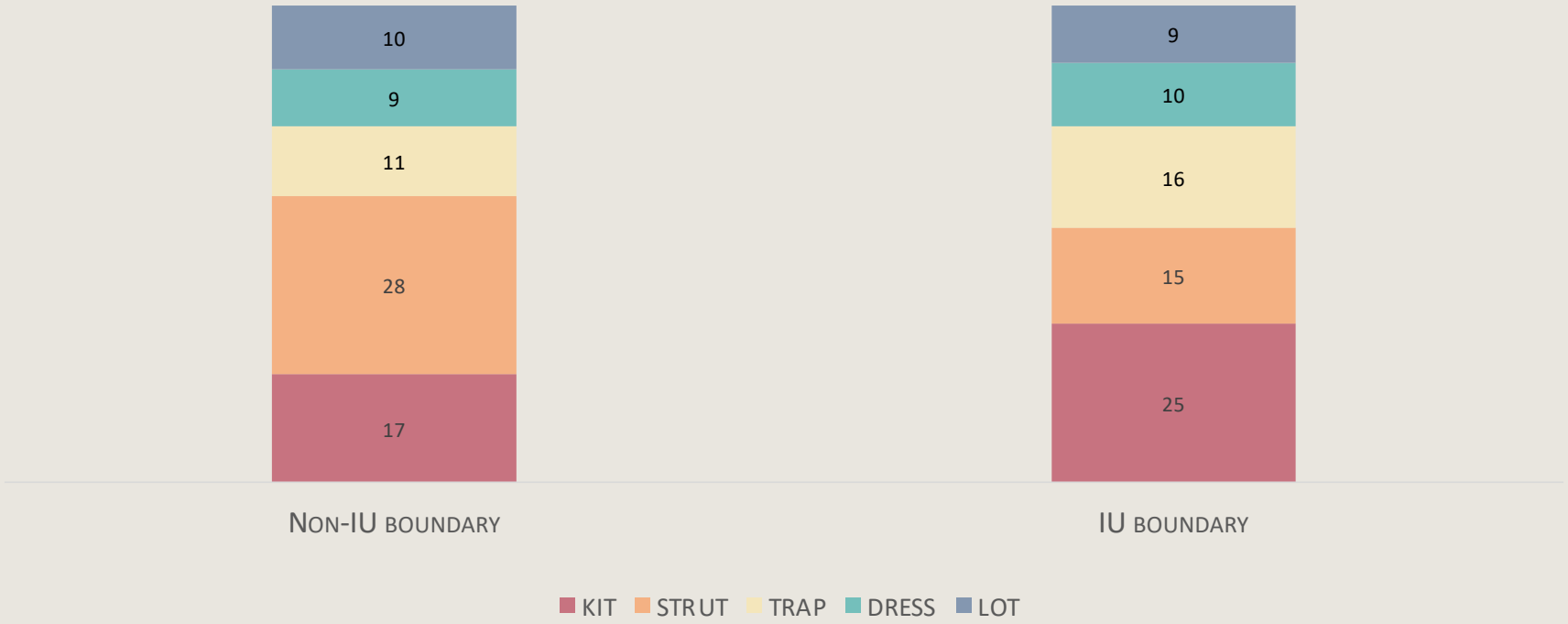


VOWEL TYPES PER ACCENTUATION STATUS



$\chi^2(8) = 5.6422$, $p = 0.69$

VOWEL TYPES PER BOUNDARY STRENGTH



$\chi^2(4) = 6.4852$, $p = 0.17$

MATERIALS AND METHOD

Multivariate regression analysis in R

dependent variable		vowel length (measured instrumentally in Praat)	
independent variables	*linguistic*	proximity to IU boundary (in n° of syllables)	
		boundary strength:	IU vs. non-IU boundary
		accentuation status:	– primary (tonic) accent – secondary (non-tonic) accent – unaccented
		vowel type:	KIT, STRUT, TRAP, DRESS, LOT
	non-linguistic	speaker	
		sex	

MATERIALS AND METHOD

Inter-rater reliability

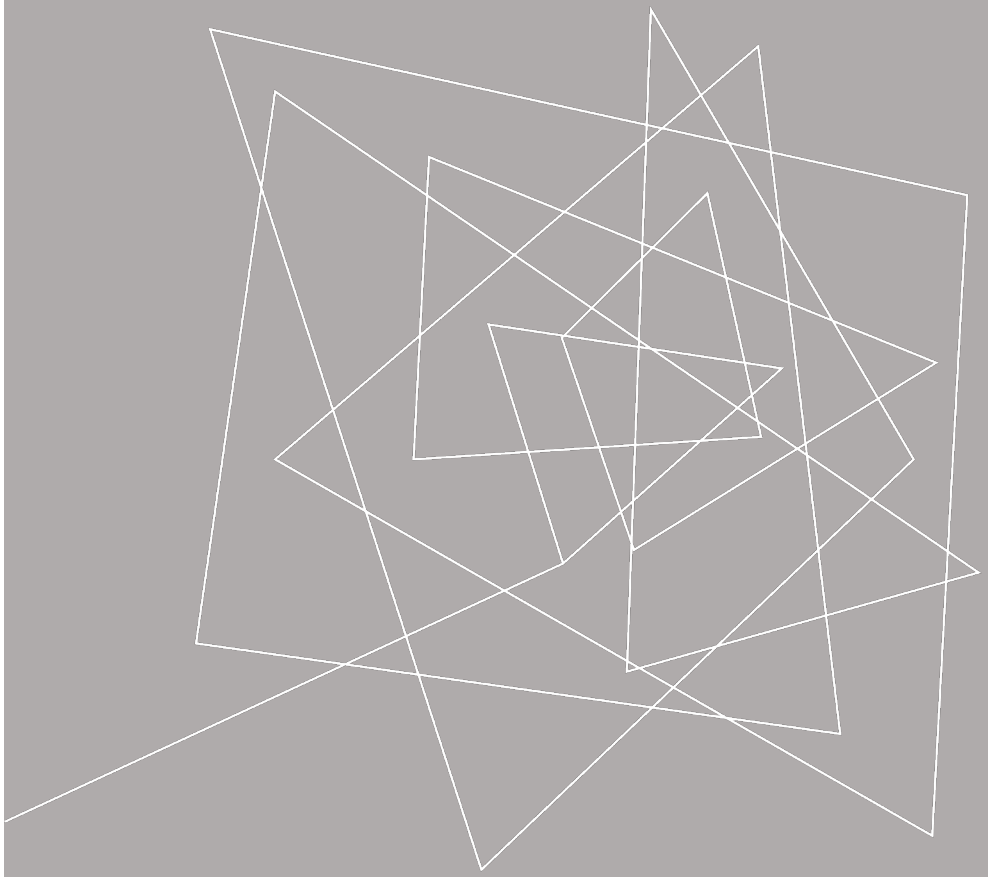
Pearson's correlation test

correlation coefficient = 0.7699107

t = 5.9105

p-value < 0.001

= individual measurements significantly correlated → sufficient inter-rater agreement



RESULTS

RESULTS

Multivariate linear regression

model_1 = lm(Length_vowel ~ Accentuation + Boundary + Proximity + VowelType + Participant + Sex)

	df	Sum Sq	Mean Sq	F Value	Pr (>F)	
Accentuation	2	0.150821	0.075411	47.9901	8.19E-16 ***	
Boundary	1	0.04691	0.04691	29.8526	2.81E-07 ***	
Proximity	1	0.004639	0.004639	2.9524	0.088489 .	→ insignificant
VowelType	4	0.022175	0.005544	3.528	0.009421 **	
Speaker	27	0.105891	0.003922	2.4958	0.000431 ***	
Sex	1	0.000734	0.000734	0.4674	0.495593	→ insignificant
Residuals	113	0.177566	0.001571			

+ high VIF scores for Speaker = suggests collinearity with other factor(s)

RESULTS

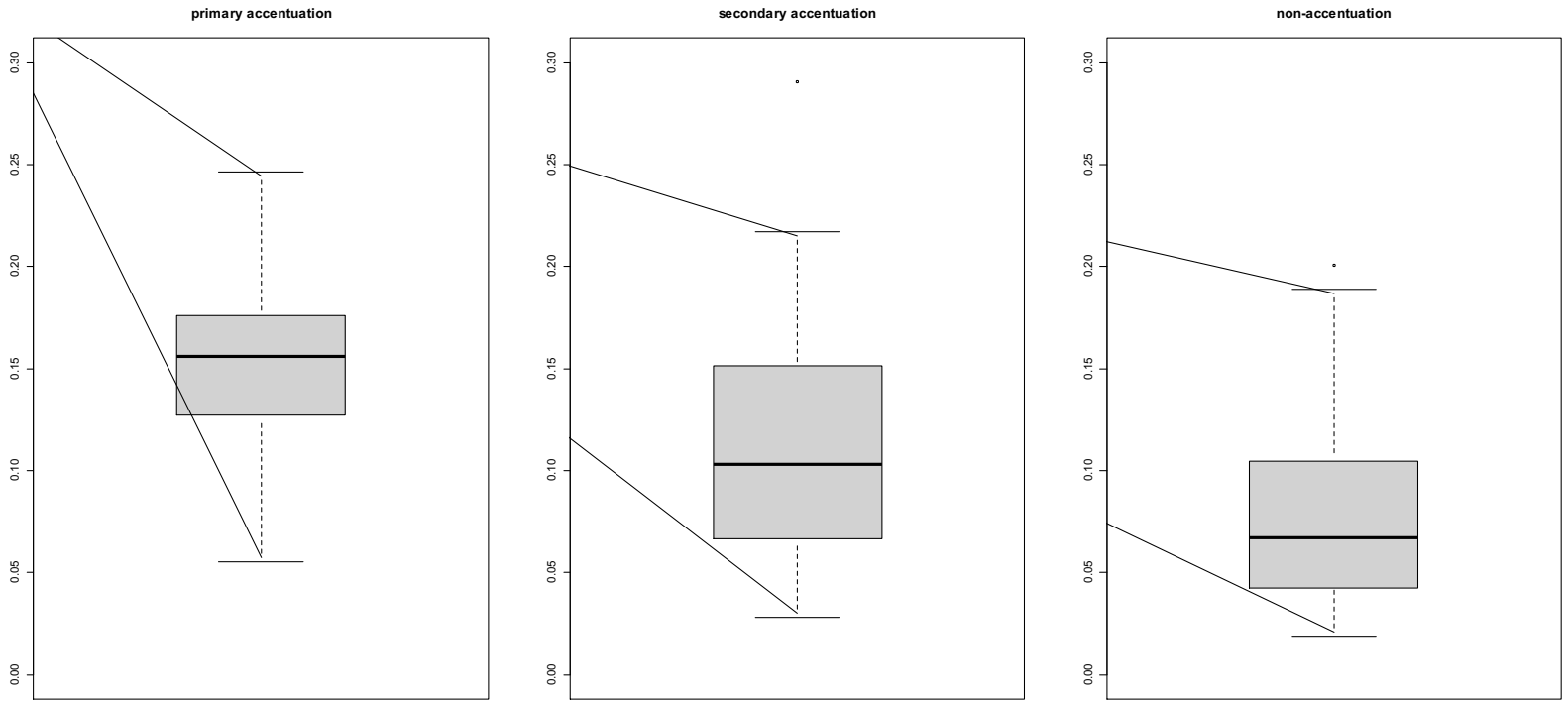
Multivariate linear regression

model_2 = lm(Length_vowel ~ Accentuation + Boundary + Proximity + VowelType)

	df	Sum Sq	Mean Sq	F Value	Pr (>F)
Accentuation	2	0.150821	0.075411	37.4146	9.23E-14***
Boundary	1	0.04691	0.04691	23.274	3.60E-06***
Proximity	1	0.004639	0.004639	2.3018	0.13146
VowelType	4	0.022175	0.005544	2.7505	0.03056*
Residuals	141	0.284192	0.002016		

Residual standard error: 0.04489 on 141 degrees of freedom
Multiple R-squared: 0.4414, Adjusted R-squared: 0.4097
F-statistic: 13.93 on 8 and 141 DF, p-value: 8.556e-15

RESULTS: ACCENTUATION STATUS



RESULTS: ACCENTUATION STATUS

Tukey post-hoc test, based on ANOVA for accentuation status

```
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = Length_vowel ~ ACC, data = data)

$ACC
                  diff         lwr         upr     p adj
SEC-PRIM    -0.04309699 -0.06646315 -0.01973083 0.0000699
UNACC-PRIM  -0.07750943 -0.10087559 -0.05414328 0.0000000
UNACC-SEC   -0.03441244 -0.05777860 -0.01104629 0.0018546
```

RESULTS: ACCENTUATION STATUS

Moreover, in subsets of syllables before non-IU vs. IU boundary, effect of accentuation status remains:

Before **non-IU** boundary

	df	Sum Sq	Mean Sq	F Value	Pr (>F)
Accentuation	2	0.0558	0.027899	1.12E+01	5.88E-05***
Residuals	72	0.1796	0.002494		

Before **IU** boundary

	df	Sum Sq	Mean Sq	F Value	Pr (>F)
Accentuation	2	0.0558	0.027899	1.12E+01	5.88E-05***
Residuals	72	0.1796	0.002494		

RESULTS: ACCENTUATION STATUS

But: Tukey post-hoc tests

Before **non-IU** boundary

	diff	lwr	upr	p adj
SEC-PRIM	-0.05105161	-0.07892584	-0.023177392	0.0001149
UNACC-PRIM	-0.08823713	-0.11611135	-0.060362905	0.0000000
UNACC-SEC	-0.03718551	-0.06505974	-0.009311291	0.0058612

Before **IU** boundary

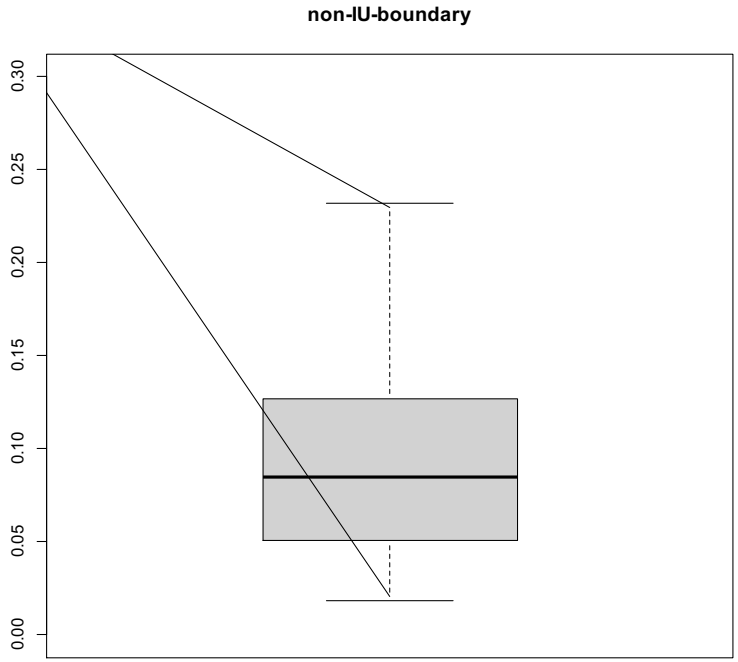
	diff	lwr	upr	p adj
SEC-PRIM	-0.03514237	-0.06894643	-0.001338301	0.0397619
UNACC-PRIM	-0.06678174	-0.10058580	-0.032977672	0.0000324
UNACC-SEC	-0.03163937	-0.06544344	0.002164695	0.0713230

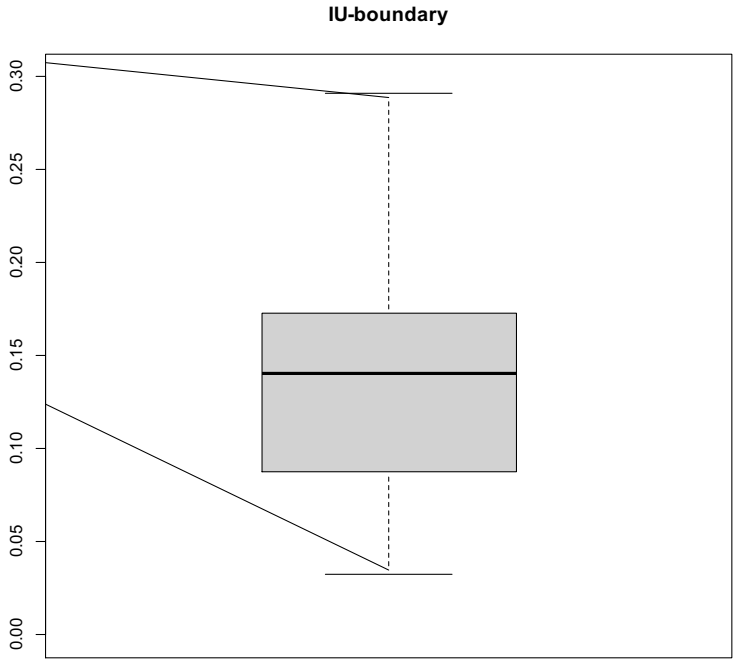
RESULTS: ACCENTUATION STATUS

But: Tukey post-hoc tests

- before non-IU boundaries, significant differences between all accentuation statuses
- before IU boundaries:
  - clear difference between primary accented and unaccented syllables ($p < 0.001$)
  - smaller but significant difference between primary and secondary accented syllables ($p = 0.03976$)
  - no difference between secondary accented and unaccented syllables ($p = 0.07$)

RESULTS: BOUNDARY



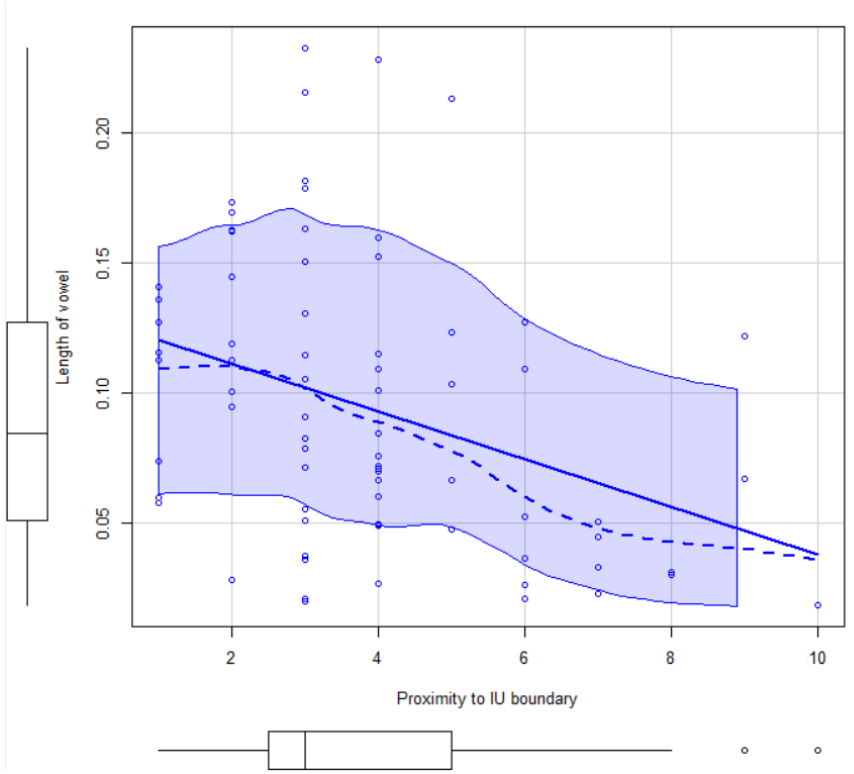


RESULTS: PROXIMITY

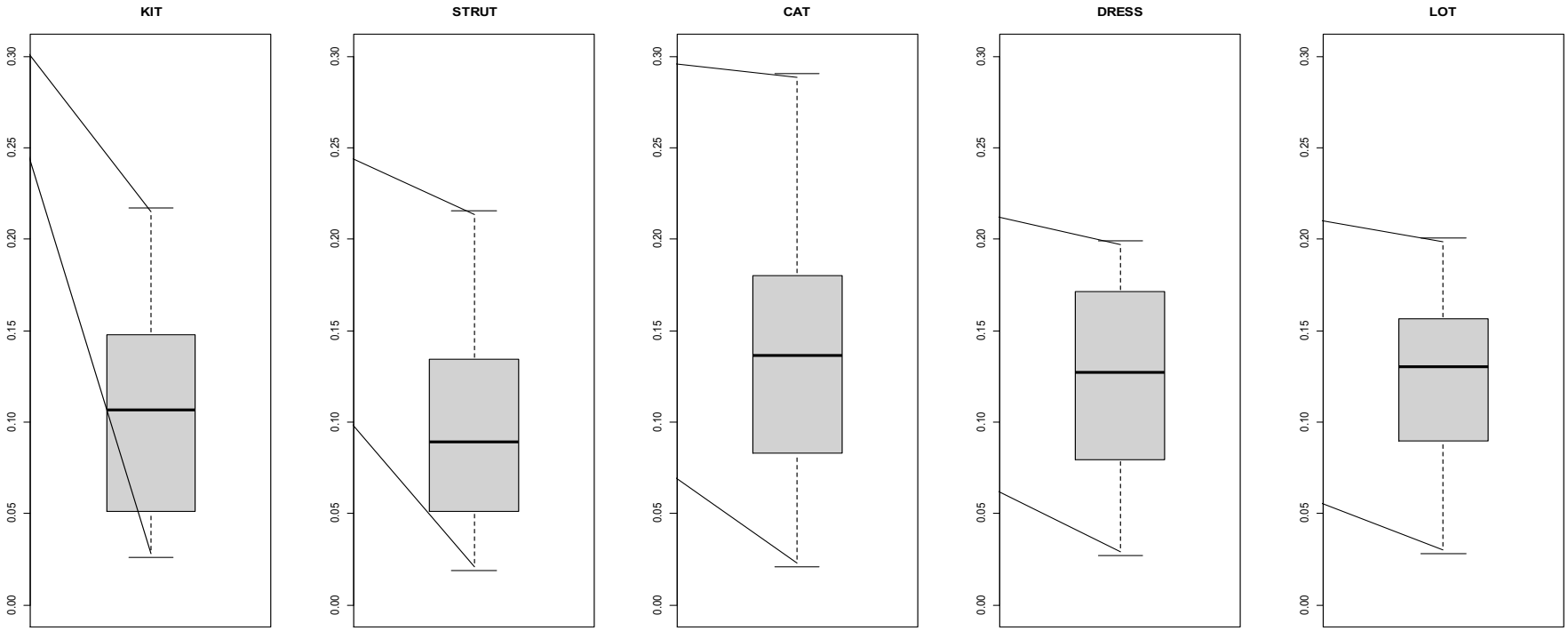
No significant result, but trend for vowel length to decrease further away from (next) IU boundary

But:

- few datapoints for vowels removed further than 4 syllables from IU boundary
- results for syllables at 1-3 syllables from IU boundary relatively similar (cf. dashed line)



RESULTS: VOWEL TYPE



RESULTS: VOWEL TYPE

Tukey post-hoc test, based on ANOVA for vowel type

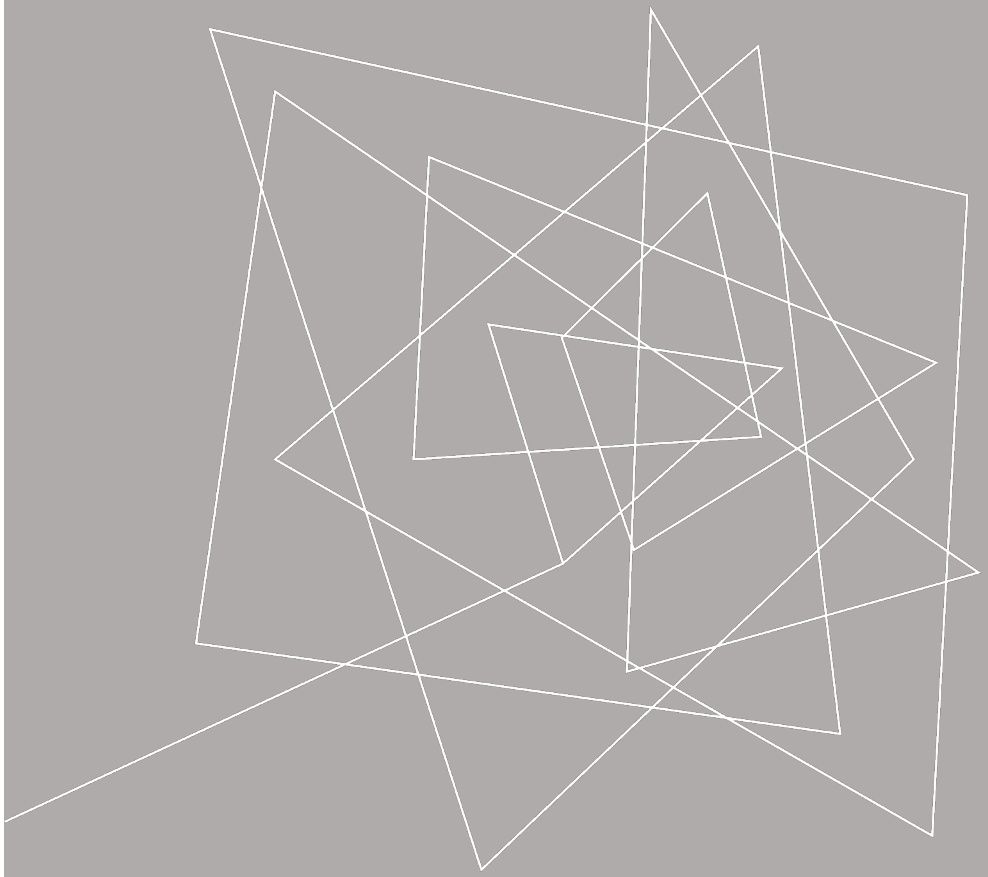
```
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = Length_vowel ~ Vowel, data = data)

$Vowel
                    diff          lwr          upr     p adj
DRESS-CAT    -0.013198248 -0.06043774  0.034041248 0.9383243
KIT-CAT      -0.035870052 -0.07478380  0.003043695 0.0862068
LOT-CAT      -0.014928990 -0.06216849  0.032310507 0.9063673
STRUT-CAT    -0.039811194 -0.07854748 -0.001074912 0.0407365
KIT-DRESS    -0.022671804 -0.06628807  0.020944464 0.6055892
LOT-DRESS    -0.001730741 -0.05291345  0.049451962 0.9999826
STRUT-DRESS -0.026612946 -0.07007096  0.016845065 0.4423177
LOT-KIT       0.020941062 -0.02267521  0.064557330 0.6753262
STRUT-KIT    -0.003941142 -0.03816552  0.030283240 0.9977590
STRUT-LOT    -0.024882204 -0.06834021  0.018575807 0.5115548
```

BAD-LAD split: /æ/-lengthening ?

RESULTS: PARTICIPANT

Tukey post-hoc test for participant actually revealed no significant differences between individual speakers, despite overall significance

Lowest *p*-value between two individual speakers: 0.057057



CONCLUSION

CONCLUSION

Convincing findings for both accentuation status and boundary strength:

- **Accentuation:** three-way distinction between primary accentuation, secondary accentuation and non-accentuation is reflected phonetically in vowel production
  → clearest difference before non-IU boundaries
  → before IU boundary, smaller difference between primary and secondary accented syllables + difference between secondary accented and non-accented syllables disappears
- **Boundary:** vowels in IU-final syllable phonetically more salient than vowels in non-IU-final position

CONCLUSION

Inconclusive findings for more fine-grained levels of **proximity** to IU boundary:

- insignificant result in regression model, but possibly due to scarcity of data points for syllables at further distances from IU-final boundary
- alternatively, phonetic strengthening effect immediately before IU boundary rather than gradual trend

No sustained effect for different vowel types:

significant difference only between STRUT (shortest) and TRAP (longest) vowels: possibly due to /æ/-lengthening

CONCLUSION

Implications

Importance of distinguishing not just between pitch accented vs. unaccented syllables (ToBI), but also between primary and secondary pitch accented syllables (nuclear tone approach)

THANK YOU

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REFERENCES

Cho, T., and Keating, P.A. 2009. Effects of initial position versus prominence in English. *Journal of Phonetics* 37: 466-485.

Edwards, J.E., Beckman, M.E., and Fletcher, J. 1991. The articulatory kinematics of ®nal lengthening. *J. Acoust. Soc. Am*. 89: 369-382.

Fougeron, C., and Keating, P.A. 1997. Articulatory strengthening at edges of prosodic domains. *J. Acoust. Soc. Am.* 101: 3728-3740.

Wightman, C.W., Shattuck-Hufnagel, S., Ostendorf, M., and Price, P.J. 1992. Segmental durations in the vicinity of prosodic phrase boundaries. *J. Acoust. Soc. Am.* 91: 1707-1717.:

```
> summary(model.rand)
Linear mixed model fit by REML ['lmerMod']
Formula: Length_vowel ~ ACC + Vowel + BI + Prox + (1 | Participant)
   Data: data

REML criterion at convergence: -453.7

Scaled residuals:
    Min      1Q  Median      3Q     Max
-1.9890 -0.6281 -0.1129  0.5325  3.0039

Random effects:
 Groups      Name        Variance  Std.Dev.
 Participant (Intercept) 0.0004914 0.02217
 Residual                0.0016122 0.04015
Number of obs: 150, groups:  Participant, 29

Fixed effects:
             Estimate Std. Error t value
(Intercept)  0.162109   0.013310  12.180
ACCSEC      -0.037768   0.008862  -4.262
ACCUNACC    -0.064930   0.009244  -7.024
VowelDRESS  -0.008490   0.012650  -0.671
VowelKIT    -0.026219   0.010569  -2.481
VowelLOT    -0.004178   0.012535  -0.333
VowelSTRUT  -0.015811   0.010670  -1.482
BI4          0.020618   0.011555   1.784
Prox        -0.004899   0.002446  -2.003

Correlation of Fixed Effects:
            (Intr) ACCSEC ACCUNA VDRESS VwlKIT VwlLOT VSTRUT BI4
ACCSEC      -0.195
ACCUNACC    -0.170  0.525
VowelDRESS -0.398  0.013 -0.033
VowelKIT    -0.415  0.084 -0.089  0.491
VowelLOT    -0.381 -0.010  0.018  0.409  0.477
VowelSTRUT -0.396  0.037 -0.030  0.509  0.603  0.509
BI4         -0.607 -0.196 -0.130  0.002 -0.084 -0.005 -0.065
Prox        -0.507 -0.203 -0.192 -0.018 -0.103 -0.070 -0.209  0.772
>
```

```
> anova(model.rand)
Analysis of Variance Table
      npar   Sum Sq  Mean Sq F value
ACC      2 0.107778 0.053889 33.4264
Vowel    4 0.017858 0.004464  2.7693
BI       1 0.044152 0.044152 27.3871
Prox     1 0.006465 0.006465  4.0102
```