Seminar session 3

Homophony in morphology

The acoustic properties of morphemic and non-morphemic word-final S and D in English

Collaborators
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The problem

Traditional assumptions

- morphemes are represented at the phonological level
- no difference between different /s/ morphemes
- homophony of plural, genitive, genitive singular, 3sg, clitics of *has, is, us*
- no difference between different /s/ morphemes
- homophony of past tense *-ed*, past participle *-ed*, adjectival *-ed*, and clitics of *had, would, did*
- morphemic and non-morphemic sounds are the same in speech production

The problem

Recent research on lexemes

- *time* and *thyme* are acoustically different (Gahl 2008)
- *like* (verb), *like* (particle) and *like* (quotative) are acoustically different (Drager 2010)
- stems are acoustically different when part of a complex word (e.g. Kemps et al. 2005, Blazej & Cohen-Goldberg 2015)

What about affixes?

- morphemic vs. non-morphemic /s/ and /d/?
- the different /s/ and /d/ morphemes in English?

Phonetics of English affixes

- Morphemic /s/ differs acoustically from non-morphemic /s/ (Walsh & Parker 1983)
- Morphemic /t/ and /d/ differ acoustically from non-morphemic /t/ and /d/ (Losiewicz 1992)
- Lots of methodological problems
- Is there also a difference between different morphemic *-s*‘s or *-d*‘s?

This paper

- Morphemic vs. different non-morphemic /s/'s:

Reanalysis of experimental data from Walsh & Parker (1983)

Analysis of natural conversation data (Buckeye corpus)

- Morphemic vs. different non-morphemic /d/'s:

Reanalysis of experimental data from Losiewicz (1992)

Analysis of natural conversation data (Buckeye corpus)

Hypotheses

- Null hypothesis 1:

  No difference in duration between morphemic and non-morphemic segments

- Null hypothesis 2:

  No difference in duration between different homophonous morphemes

/s/

Walsh & Parker 1983

- /ks, ps, ts/: *laps – lapse* *wrecks – Rex* *hearts – Hartz*
- NB: **plural** /s/ vs. **non-morphemic** /s/
- Reading experiment, three conditions (N=168)

1 ‘reasonably natural‘ context

I ran two laps today

My insurance is going to lapse today

2 ‘semantically neutral‘ context

The laps bothered him

The lapse bothered him

3 ‘semantically anomalous‘ context

Take a laps a day

Take a lapse a day

Walsh & Parker: Data

Table I Duration of morphemic and non-morphemic /s/ for all tokens obtained from Condition 1 (ms)

Speakers	1	2	3	4	5	6	7	8	9	10	$\bar{X}$
hearts	70	80	70	75	75	115	85	65	135	70	84
Hartz	70	60	110	75	50	75	70	75	100	60	77
wrecks	70	70	110	110	75	100	60	80	80	65	82
Rex	55	85	70	120	55	80	65	75	85	50	74
laps	100	85	65	110	70	65	70	80	70	100	82
lapse	60	65	60	115	70	100	70	55	70	60	73
morphemic /s/											83
non-morphemic /s/											74

Walsh & Parker: Data

Table II Duration of morphemic and non-morphemic /s/ for all tokens obtained from Condition II ("(The) _____ bothered him.") (ms)

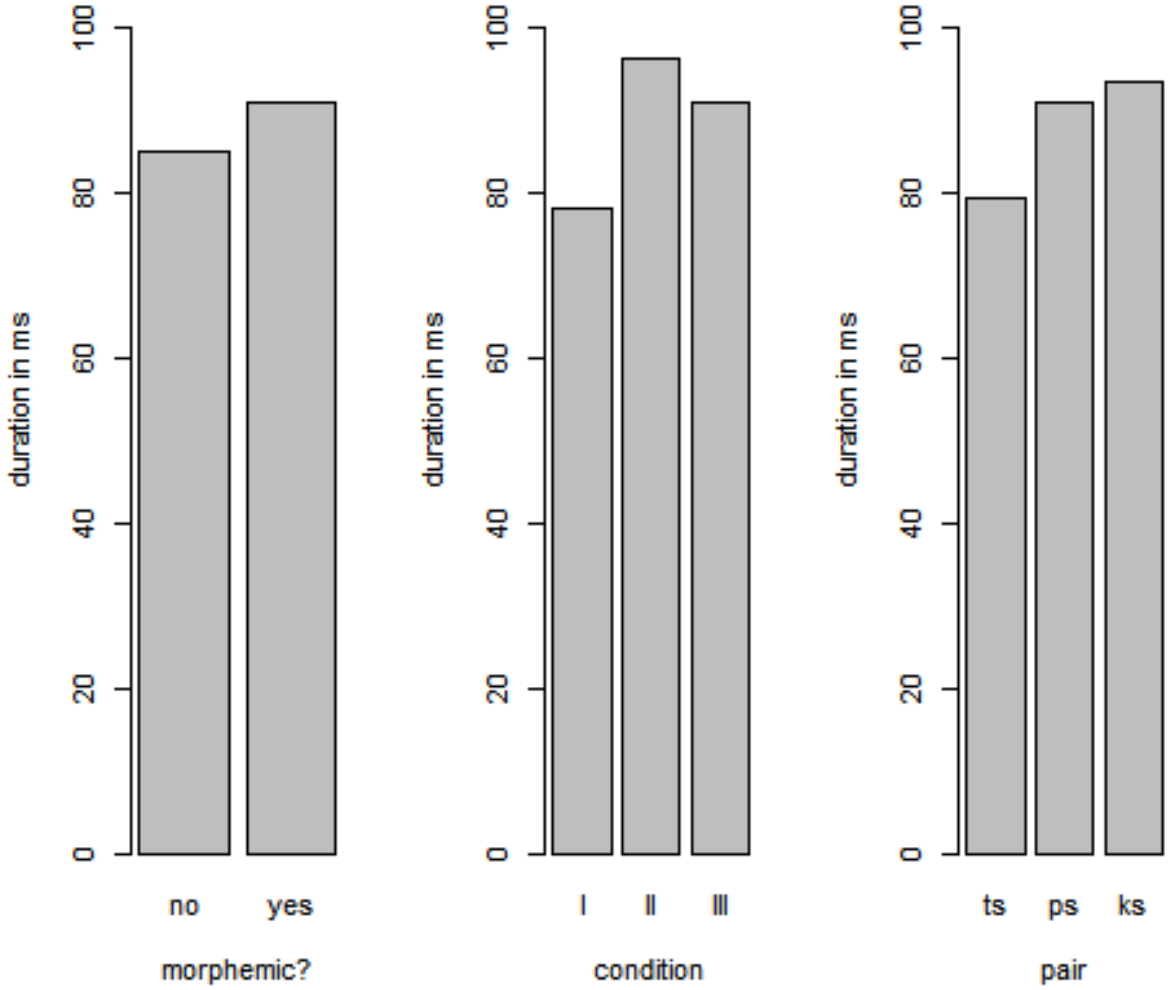
Speakers	1	2	3	4	5	6	7	8	$\bar{X}$
hearts	55	80	60	120	60	90	112	65	80
Hartz	40	70	50	90	80	135	85	30	73
wrecks	45	170	75	170	90	140	135	125	119
Rex	35	135	80	145	90	100	100	100	98
laps	45	115	110	140	90	110	130	90	104
lapse	65	115	80	195	70	100	125	85	107
morphemic /s/									101
non-morphemic /s/									92

Walsh & Parker: Data

Table III Duration of morphemic and non-morphemic /s/ for all tokens obtained from Condition III ("Take ____ a day".) ms

Speakers	1	2	3	4	5	6	7	8	9	10	$\bar{X}$
hearts	95	75	90	55	60	100	75	130	65	75	82
Hartz	100	70	95	85	65	105	90	75	50	90	83
wrecks	110	85	125	100	60	100	100	95	90	85	95
Rex	95	60	140	115	85	115	95	110	85	87	99
laps	90	110	100	95	70	75	80	130	110	110	97
lapse	115	110	95	110	50	95	90	110	75	70	92
morphemic /s/											91
non-morphemic /s/											91

Walsh & Parker: Results (mean durations)



Reanalysis of the data: Method

Mixed effects multiple regression

- look at the independent effect of each variable in the presence of others
- statistically control for random variables

Dependent variable

- Duration of /s/ (Box-Cox-transformed, λ = 0.030303)

Fixed effects

- morphemic status (`yes, no`)
- condition (`1, 2, 3`)
- pair (/`ks, ps, ts`/)
- orthography (1, 2, 3 letters)
- word frequency (from COHA, 1960s-80s)
- interactions of the above

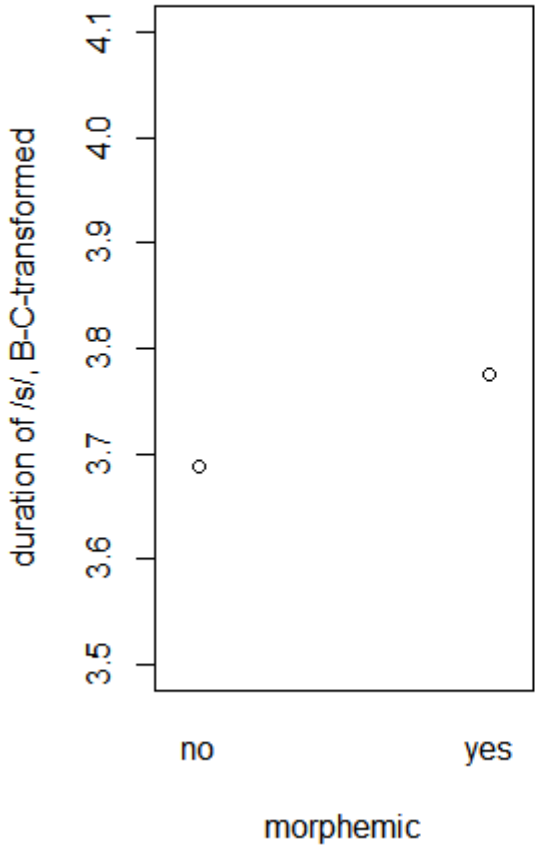
Random effects

- Random intercepts for subjects, random contrasts/slopes for subjects by condition, by pair, and by frequency

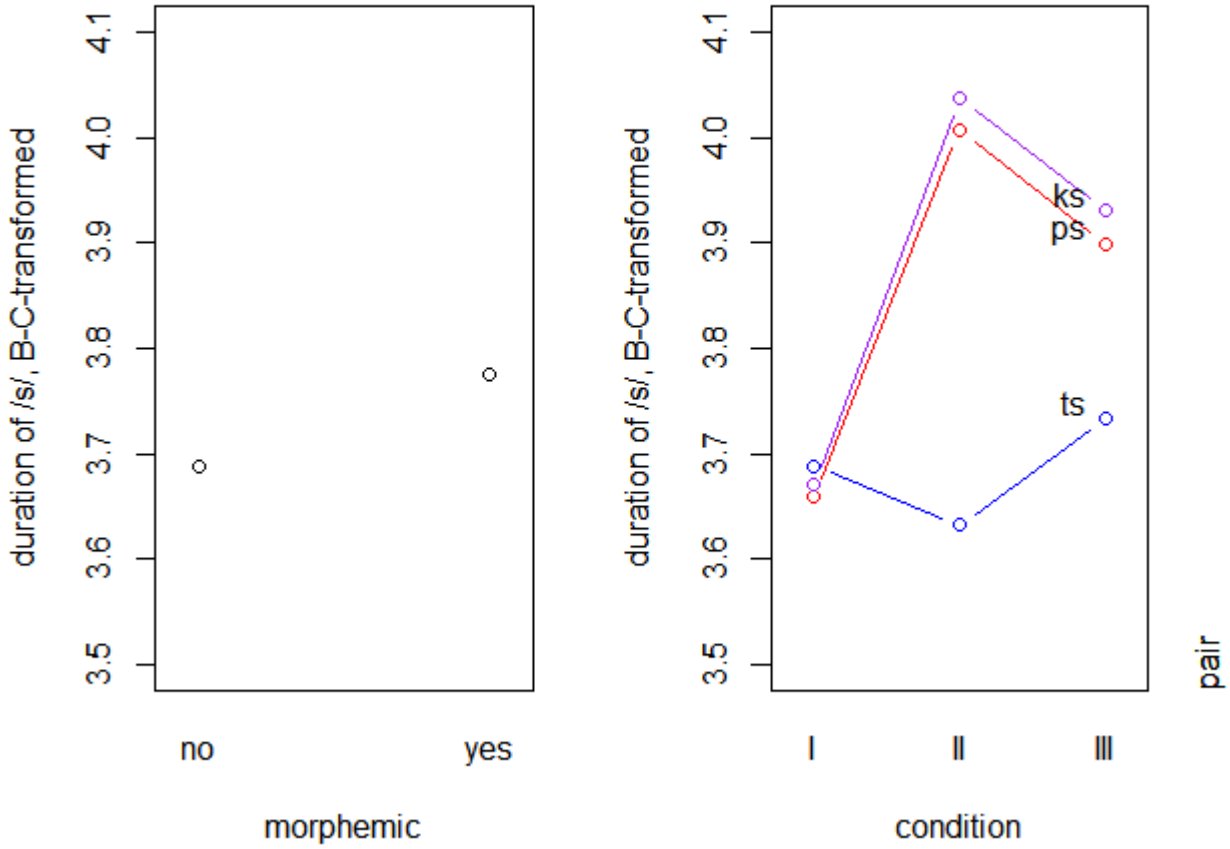
Final model

- significant effect of MORPHEMIC status
- significant interaction of CONDITION with PAIR
- only random intercepts for subject, no random contrasts

Reanalysis: results



Reanalysis: results



Interpretation

- Significant effect of morphemic status in production:

  plural /s/ is longer than non-morphemic /s/

- Effect is quite small (c. 6 ms) and way below the perceptual threshold (c. 25-30 ms, Klatt & Cooper 1975, Shatzman & McQueen 2006)

- Puzzling effect of condition and pair

- natural context: all pairs behave in the same way

- unnatural contexts: /ks/ and /ps/ behave differently from /ts/

- An effect of conditional transitional probability of phonemes?

- No:

/ts/	/ps/	/ks/
0.015	0.015	0.08

Our study: Research questions

(Plag, Homann & Kunter 2015, *Journal of Linguistics*)

1. Is there a difference between morphemic and non-morphemic */s/?*

2. Is there a difference between different morphemic /s/'s, and if so,

3. Is this difference observable in natural speech (as against experiments)?

We start with question 2.

Suffix homophony in English: *-s*

Bauer, Lieber & Plag (2013) *The Oxford Reference Guide to English Morphology.* Oxford: OUP

- Plural

"the allomorphs are /s/, /z/, and /ɪz/, where /ɪz/ occurs after sibilants, /s/ occurs after other voiceless consonants, and /z/ occurs elsewhere ... This allomorphy is easily understood in phonological terms (assimilation and epenthesis to break up illegal geminates), and is not controversial" (p. 15)

- 3rd person singular

"Verbs ending in a sibilant ... take the allomorph /ɪz/ or /əz/, all other bases take either /z/ or /s/, depending on the final segment of the base. If the base ends in a voiced segment the voiced allomorph /z/ is chosen, if not, the unvoiced allomorph /s/ is chosen" (p. 69)

Suffix homophony in English: *-s*

- At the form level (= phonological level) the two morphemes are identical

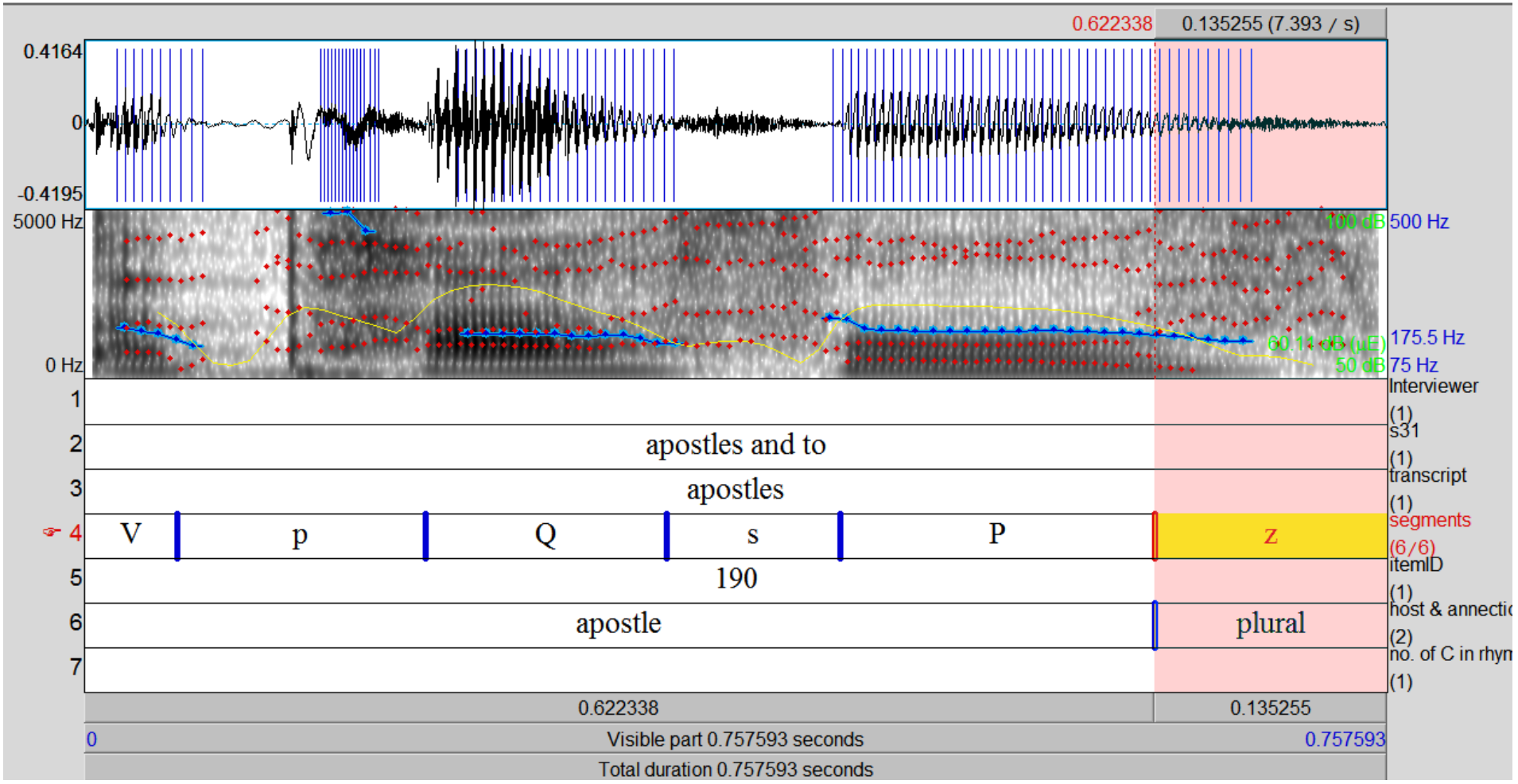
- Current models do not have another form level (‘post-lexical‘ phonology is not sensitive to morphology)

Is there another level of form where the different morphemes are not identical?

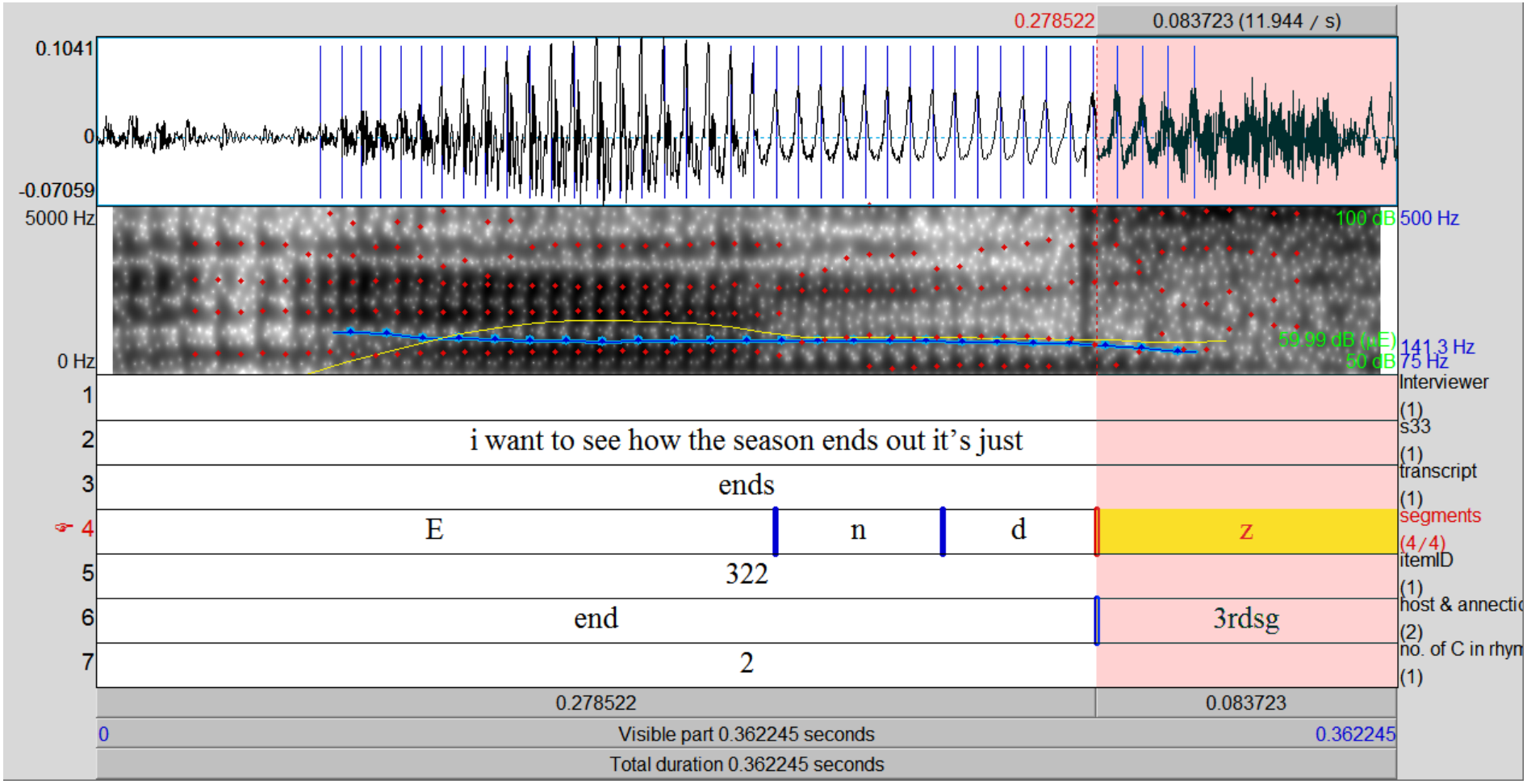
Methodology

- /z/ and /s/ (henceforth ‘S‘)
- plural, genitive, genitive singular, 3sg, clitics of *has, is*
- Buckeye Corpus, acoustic analysis, N = 447, up to 100 per category
- Natural conversations, North American English
- Statistical analysis: duration by morpheme type, LMER, beta regression
- Data illustration: *apostles* (PLURAL) and *ends* (3SG)

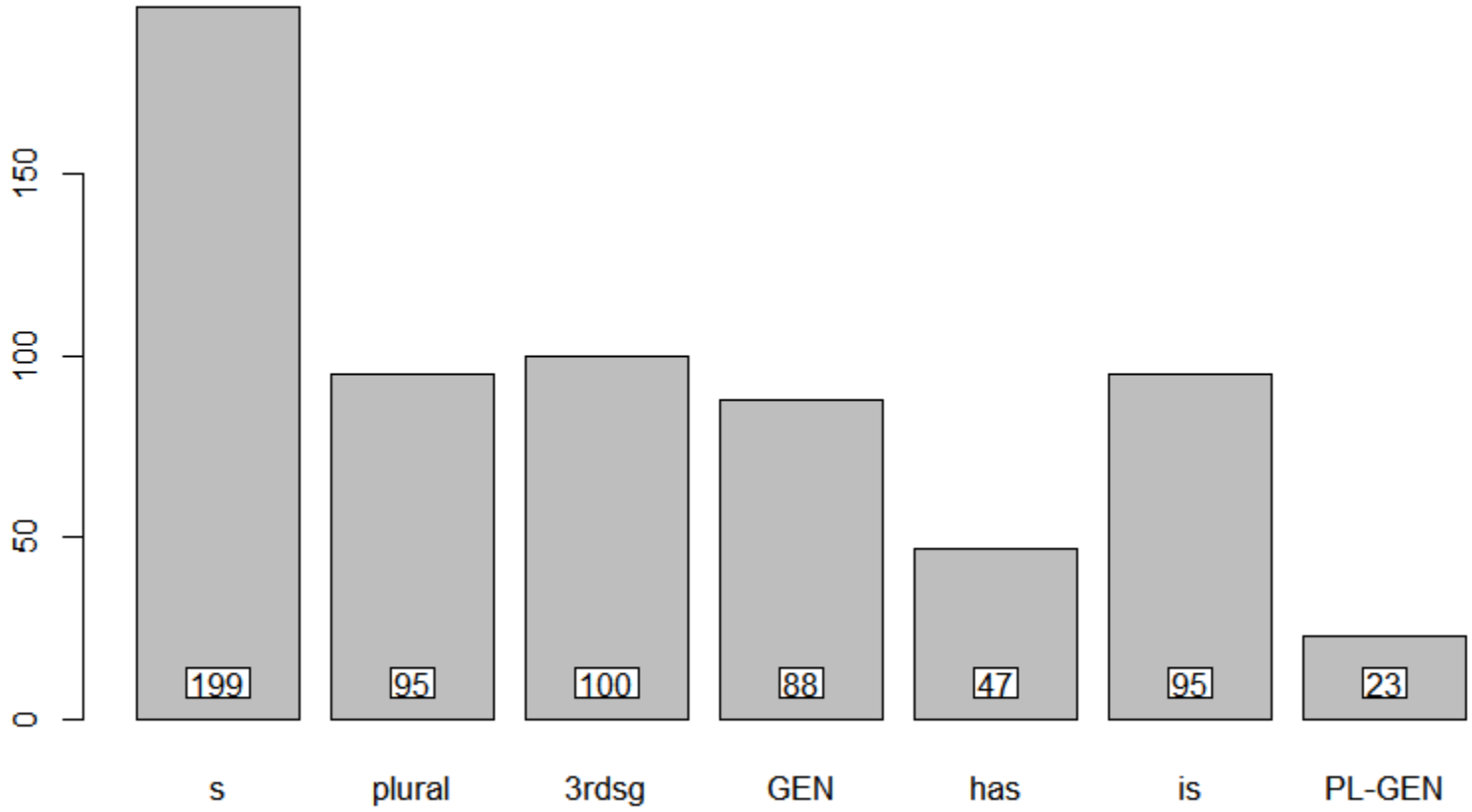
The data: Illustration



The data: Illustration



The data


0
50
100
150
199
95
100
88
47
95
23
s
plural
3rdsg
GEN
has
is
PL-GEN

The data

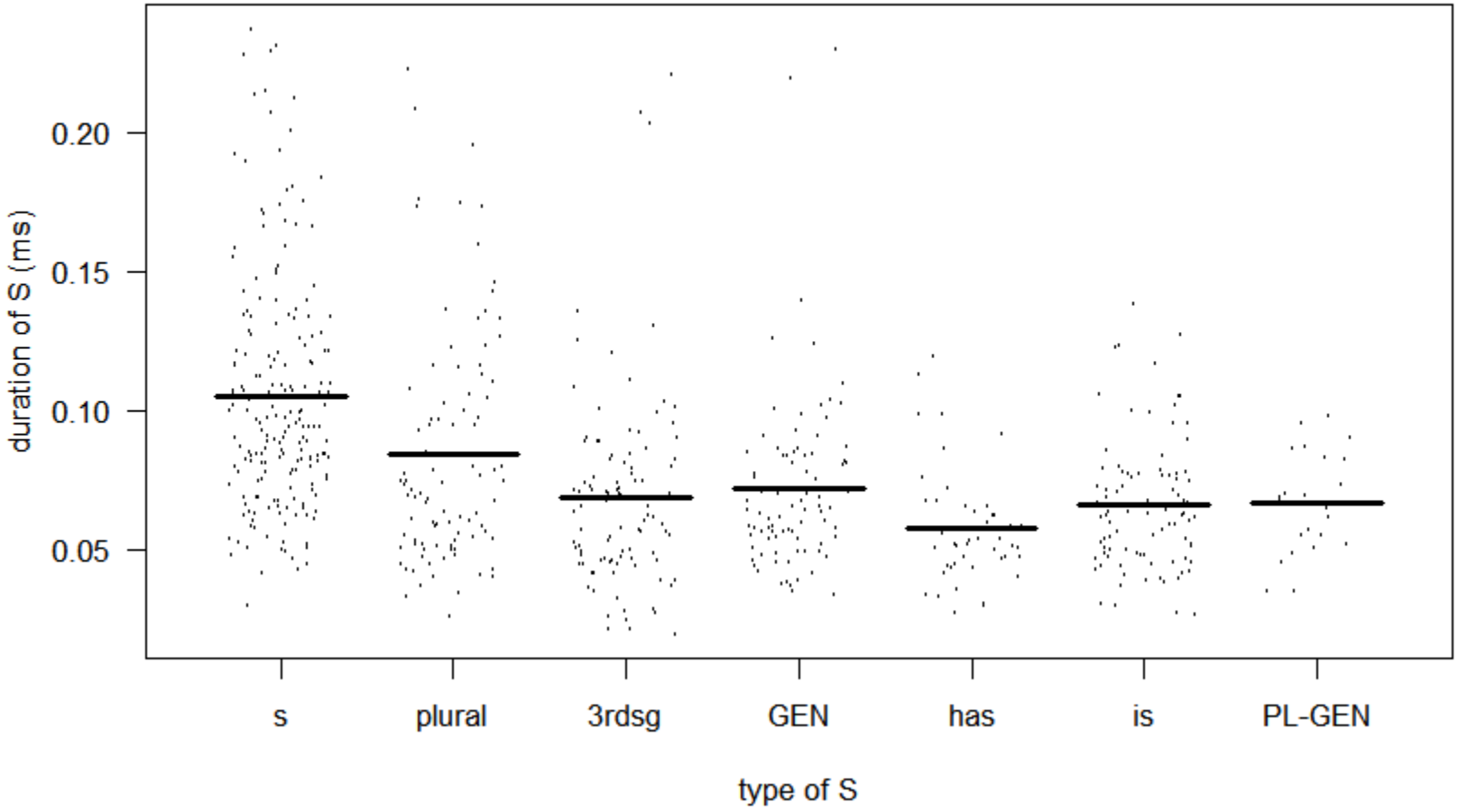

duration of S (ms)
0.20
0.15
0.10
0.05
s
plural
3rdsg
GEN
has
is
PL-GEN
type of S

Table 1: Multiple comparison of means of duration of S (Tukey contrasts). (Significance codes: '***' $p<0.001$ '*' $p<0.01$, '*' $p<0.05$)

	Estimate	Std. Error	t value	Pr(> |t|)	
plural - s	-0.0210570	0.0052977	-3.975	0.00154	**
3rdsg - s	-0.0361719	0.0046476	-7.783	<0.001	***
GEN - s	-0.0333925	0.0045509	-7.337	<0.001	***
has - s	-0.0474129	0.0042647	-11.118	<0.001	***
is - s	-0.0387739	0.0038523	-10.065	<0.001	***
PL-GEN - s	-0.0385812	0.0049358	-7.817	<0.001	***
3rdsg - plural	-0.0151149	0.0056085	-2.695	0.09851	.
GEN - plural	-0.0123355	0.0055286	-2.231	0.27464	
has - plural	-0.0263559	0.0052955	-4.977	<0.001	***
is - plural	-0.0177169	0.0049694	-3.565	0.00697	**
PL-GEN - plural	-0.0175242	0.0058495	-2.996	0.04356	*
GEN - 3rdsg	0.0027794	0.0049092	0.566	0.99761	
has - 3rdsg	-0.0112410	0.0046450	-2.420	0.18775	
is - 3rdsg	-0.0026020	0.0042695	-0.609	0.99640	
PL-GEN - 3rdsg	-0.0024093	0.0052680	-0.457	0.99929	
has - GEN	-0.0140204	0.0045483	-3.083	0.03370	*
is - GEN	-0.0053814	0.0041641	-1.292	0.85201	
PL-GEN - GEN	-0.0051887	0.0051829	-1.001	0.95232	
is - has	0.0086390	0.0038492	2.244	0.26811	
PL-GEN - has	0.0088317	0.0049334	1.790	0.54849	
PL-GEN - is	0.0001927	0.0045816	0.042	1.00000	

Analysis

- Many other potential influences (covariates)
- Multiple regression
- predict duration of *S* on the basis of type of morpheme

Covariates (selection)

- voicing
- number of consonants in rhyme
- number of syllables in host
- context (in utterance: *middle* or *final,* following consonant, before a phrase-final boundary)
- frequency
- speech rate (local, non-local)
- N-gram frequencies, phonological neighbors, orthographic neighbors ...

Covariates

Table 2: Summary of the dependent variables and covariates used in the initial models.

Dependent variables	N	Mean	St. Dev.	Min	Max
Absolute duration of S: DURATIONOFS	644	0.081	0.039	0.019	0.237
Relative duration of S: PROPORTIONS	644	0.206	0.082	0.055	0.688
Numerical predictors	**N**	**Mean**	**St. Dev.**	**Min**	**Max**
Local speech rate: SYLSEC	644	5.601	1.202	1.984	10.179
Base duration: BASEDURATION	644	0.329	0.134	0.029	1.052
Base frequency: LOGBASEFREQ	644	8.672	2.399	0.000	14.146
Previous mention: BASEREP	644	0.317	0.772	0	6
Bigram frequency: LOGRBIGRAM	548	2.542	2.739	0.000	9.884
Neighborhood density: PND	601	14.21797	14.8551	0	60
Categorical predictors:	**N**	**Levels**			
No. of cons. before S: CONSONANTS	644	0: 325	1: 259	2: 58	3: 2
Voicing: ISVOICED	644	yes: 81	no: 563		
Following context: FOLLCONTEXT	644	pause: 97	V: 170	APP: 68	N: 33
		AFF: 10	F: 143	P: 123	
Syntactic position: BOUNDARY	644	yes: 226	no: 418		
Explanatory variable	**N**	**Levels**			
Type of S: TYPEOFS	644	S: 196	PL: 95	3rdsg: 100	GEN: 88
		has: 47	is: 95	PL-GEN: 23	

Statistical analysis

- Model 1: **absolute** length of S as dependent variable (LMER)

- Model 2: **relative** length of S (i.e. proportion of S) as dependent variable (beta regression)

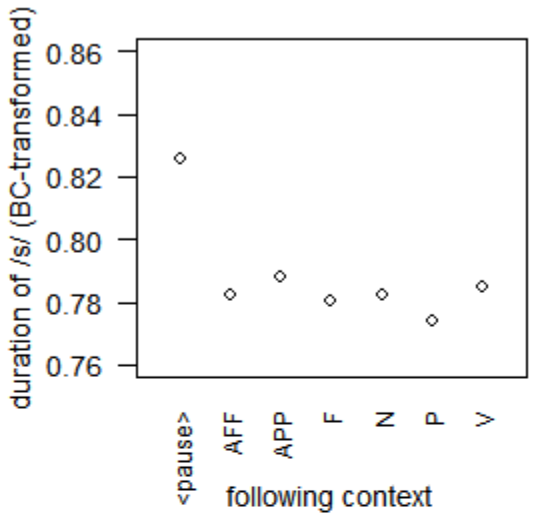
- **Null hypothesis 1**

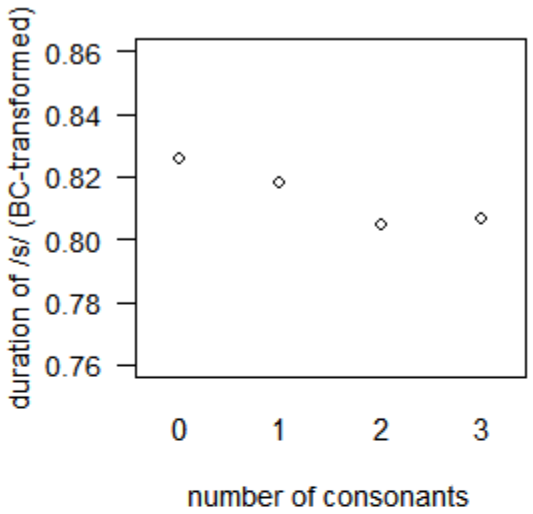
  No difference in duration between the different morphemes

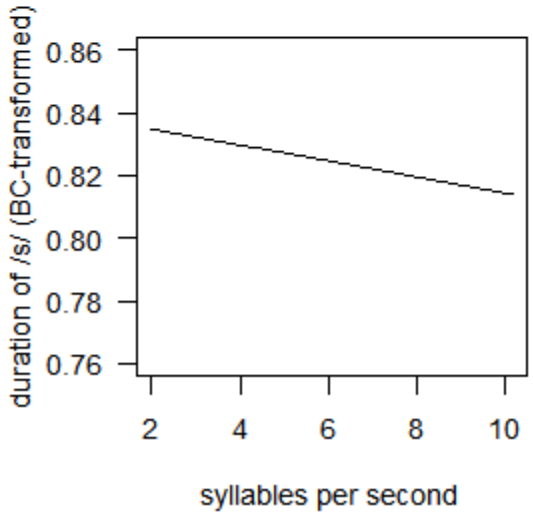
- **Null hypothesis 2**

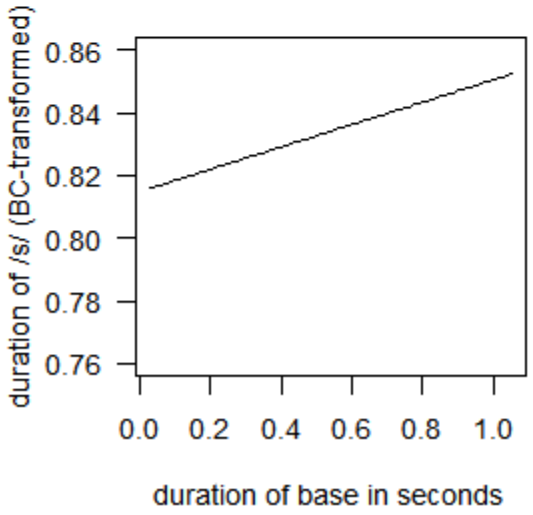
  No difference in duration between morphemic and non-morphemic S

Absolute length: Effects of covariates

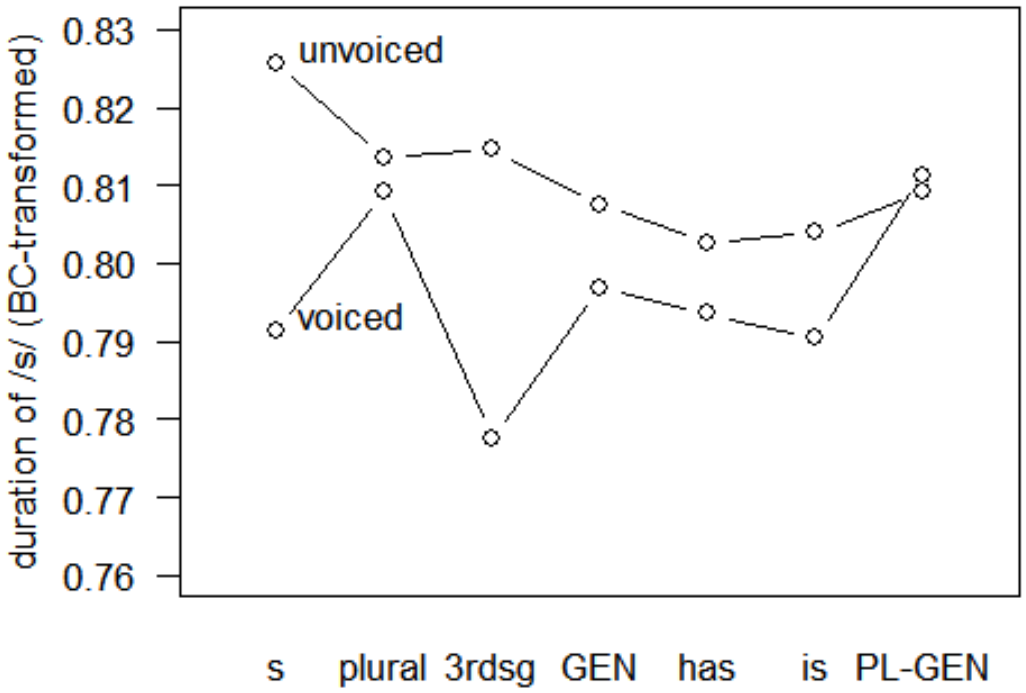








Absolute length: Effect of MORPHEME



Significant differences

Table 5: Significant contrasts in duration between different types of voiced S. Significance codes: '***' $p<0.001$ '*' $p<0.01$, '*' $p<0.05$

	S	PL	3RDSG	GEN	HAS	IS	PL-GEN
S	n.a.						
PL		n.a.	*			*	
3RDSG			n.a.	*			*
GEN				n.a.			
HAS					n.a.		
IS						n.a.	
PL-GEN							n.a.

Table 6: Significant contrasts in duration between different types of unvoiced S. Significance codes: '***' $p<0.001$ '*' $p<0.01$, '*' $p<0.05$

	S	PL	3RDSG	GEN	HAS	IS	PL-GEN
S	n.a.	**	*	***	***	***	**
PL		n.a.			*	*	
3RDSG			n.a.		*	*	
GEN				n.a.			
HAS					n.a.		
IS						n.a.	
PL-GEN							n.a.

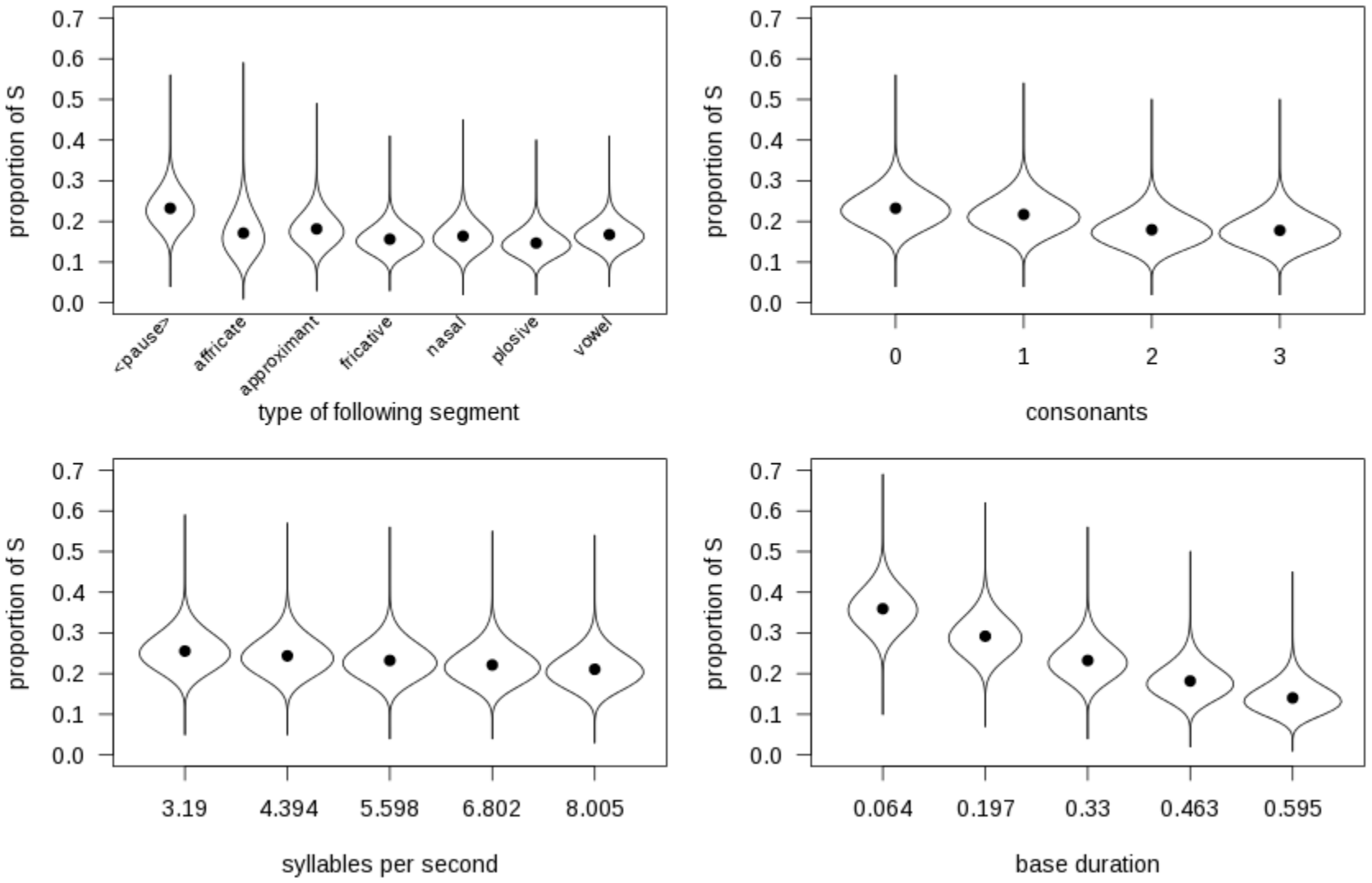
Summary: Absolute duration

- We find robust differences between different types of S

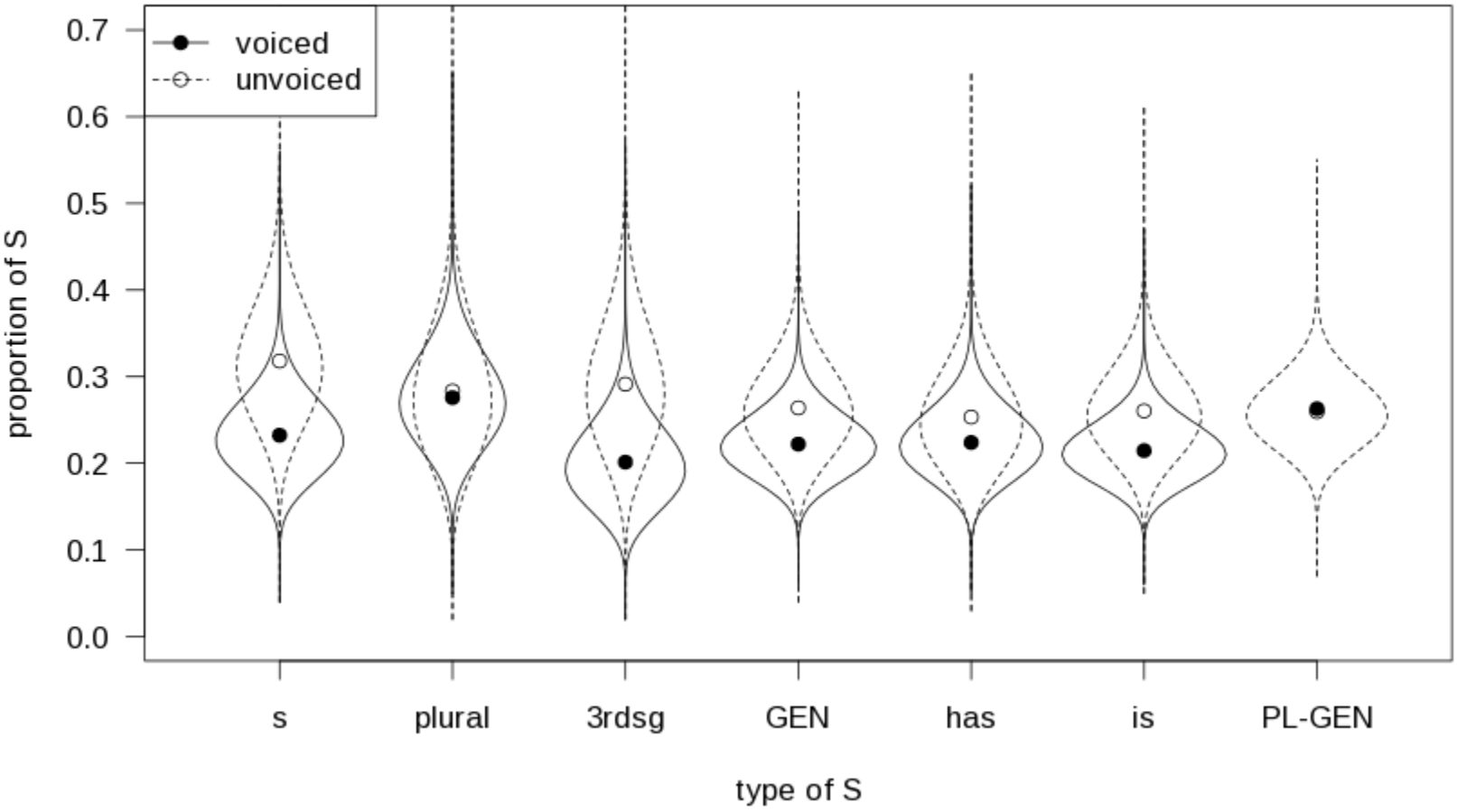
- Voiced realizations
  - 3sg is different from plural and plural genitive

- Unvoiced realizations
  - non-morphemic S is longer than all morphemic S‘s
  - Duration hierarchy:
    Non-morphemic S > suffix S > clitic S

Relative duration: Covariates



Relative duration: Type of S



Relative duration: Contrasts

Table 9: Significant contrasts in relative duration between different types of voiced S.

	s	plural	3rdsg	GEN	has	is	PL-GEN
s	n.a.	*					
plural		n.a.	**	**	*	*	
3rdsg			n.a.				**
GEN				n.a.			*
has					n.a.		
is						n.a.	*
PL-GEN							n.a.

Significance codes: *** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$

Table 10: Significant contrasts in relative duration between different types of unvoiced S.

	s	plural	3rdsg	GEN	has	is	PL-GEN
s	n.a.	***	**	***	***	***	***
plural		n.a.			*	*	
3rdsg			n.a.	**	**	**	**
GEN				n.a.			
has					n.a.		
is						n.a.	
PL-GEN							n.a.

Significance codes: *** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$

Summary: Relative duration

- We find even more differences between different types of S

- Voiced realizations
  - Plural is different from everything else (exc. plural genitive)

- Unvoiced realizations
  - non-morphemic S is longer than all morphemic S‘s
  - Duration hierarchy:
    Non-morphemic S > suffix S > clitic S

Discussion

- Both null hypotheses need to be rejected for both absolute and relative duration
- Walsh & Parker 1983: very small difference between plural and non-morphemic S, but in the other direction
- Song et al. 2013 (CDS): small difference between morphemic S (3rd sg and plural) and non-morphemic S only in utterance-final position, same direction as Walsh & Parker
- Perception: our differences should be perceivable (47 ms mean difference between longest and shortest)

Explanations 1: Morpho-phonetics

- Morphological boundary strength directly translates into phonetic strength, even if negatively:

  No boundary > suffix boundary > clitic boundary

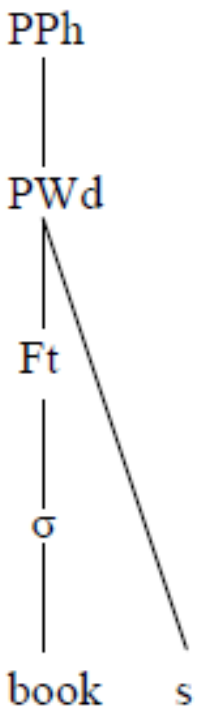
- Phonetic information is lexically represented

- Pro exemplar-based models
  differential behavior w.r.t. voicing and duration
  different distributions of properties across morphemes

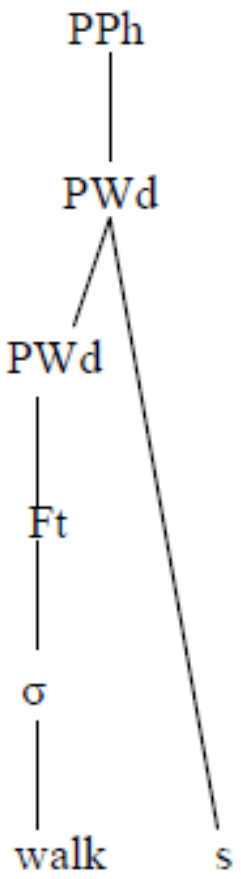
- Contra purely exemplar-based models
  effects of covariates

Explanations 2: Prosody

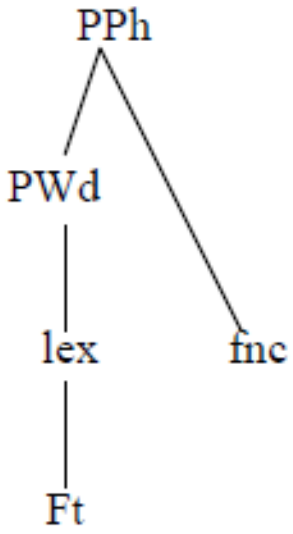
a. Internal clitic



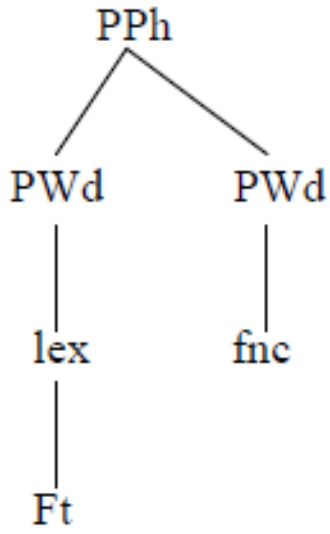
b. Affixal clitic



c. Free clitic



d. Independent PWd



(e.g. Selkirk 1997)

Prosody: Problems

- independent evidence for the proposed structures is weak
- plural and 3rdsg do not differ
- interaction with voicing
- negative correlation between boundary strength and duration

Other phonetic cues?

Center of gravity

Analysis

- predict center of gravity of S on the basis of type of morpheme
- LMER:
  - dependent variable: **center of gravity of S** (weighted by absolute spectrum, Box-Cox transformed)
  - independent variable of interest: **type of S**
  - **covariates** (selection)

    voicing

    frequency

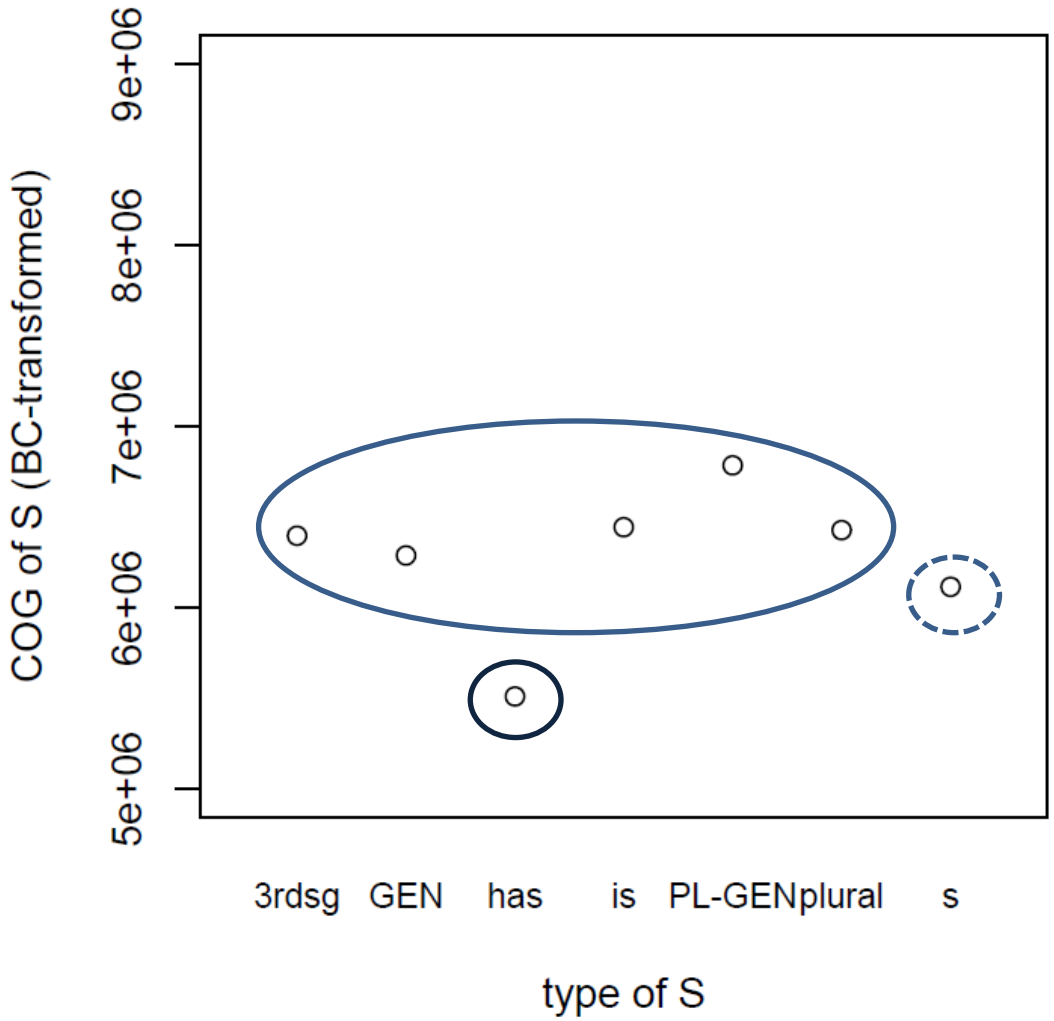
    speech rate (local, non-local)

    N-gram frequency

    phonetic environment

    length of S

Effect of TYPE OF S



S COG: summary

- We find differences between some morphemes
- We find a marginal difference between one morpheme and non-morphemic S
- Unpredicted and unaccounted for by any theory

/d/

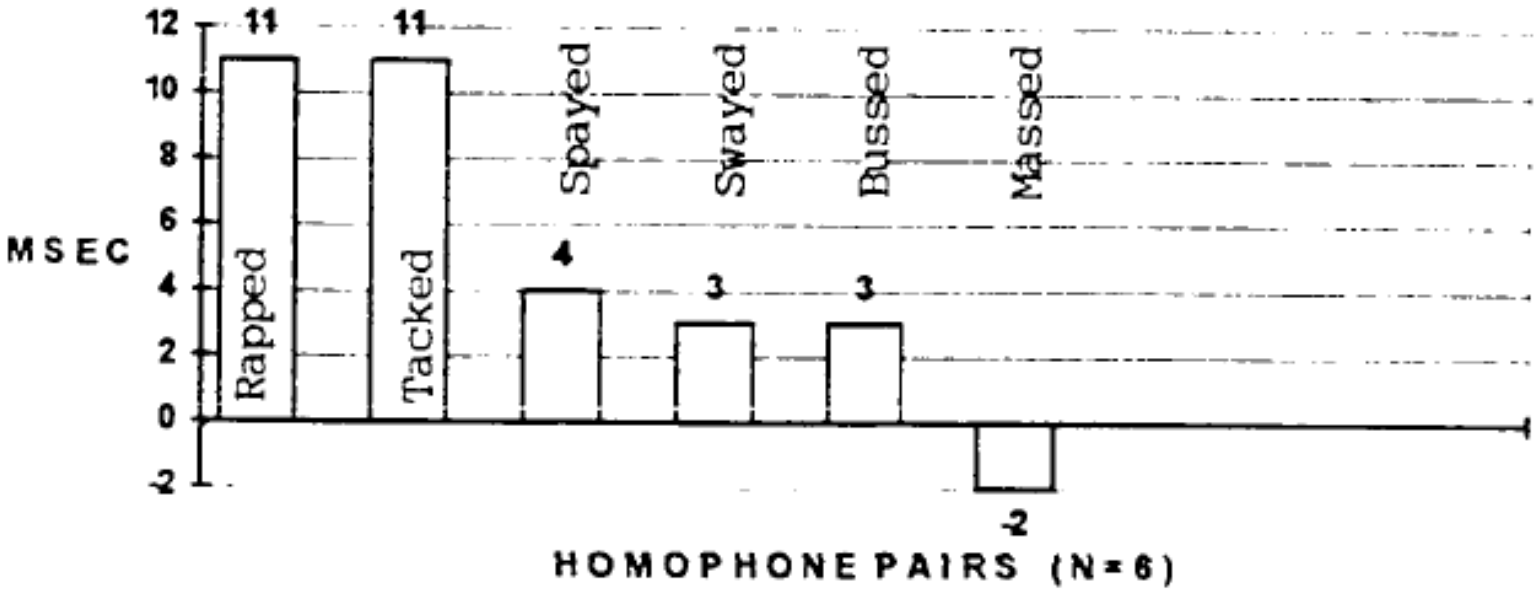
Losiewicz 1992

spade - spayed
bussed - bust

suede - swayed
massed - mast

tacked – tact
rapped - rapt

- 166 tokens, reading of word list
- morphemic sound 5 ms longer than non-morphemic sounds



Problems with Losiewicz (1992)

- small data set, word list pronunciations
- uncontrolled variables:
  /d/ vs. /t/, phonological context, part-of-speech, pair, speaker
- insufficient statistical analysis (only t-test)
- Reanalysis of the data set is difficult due to massive collinearity problems

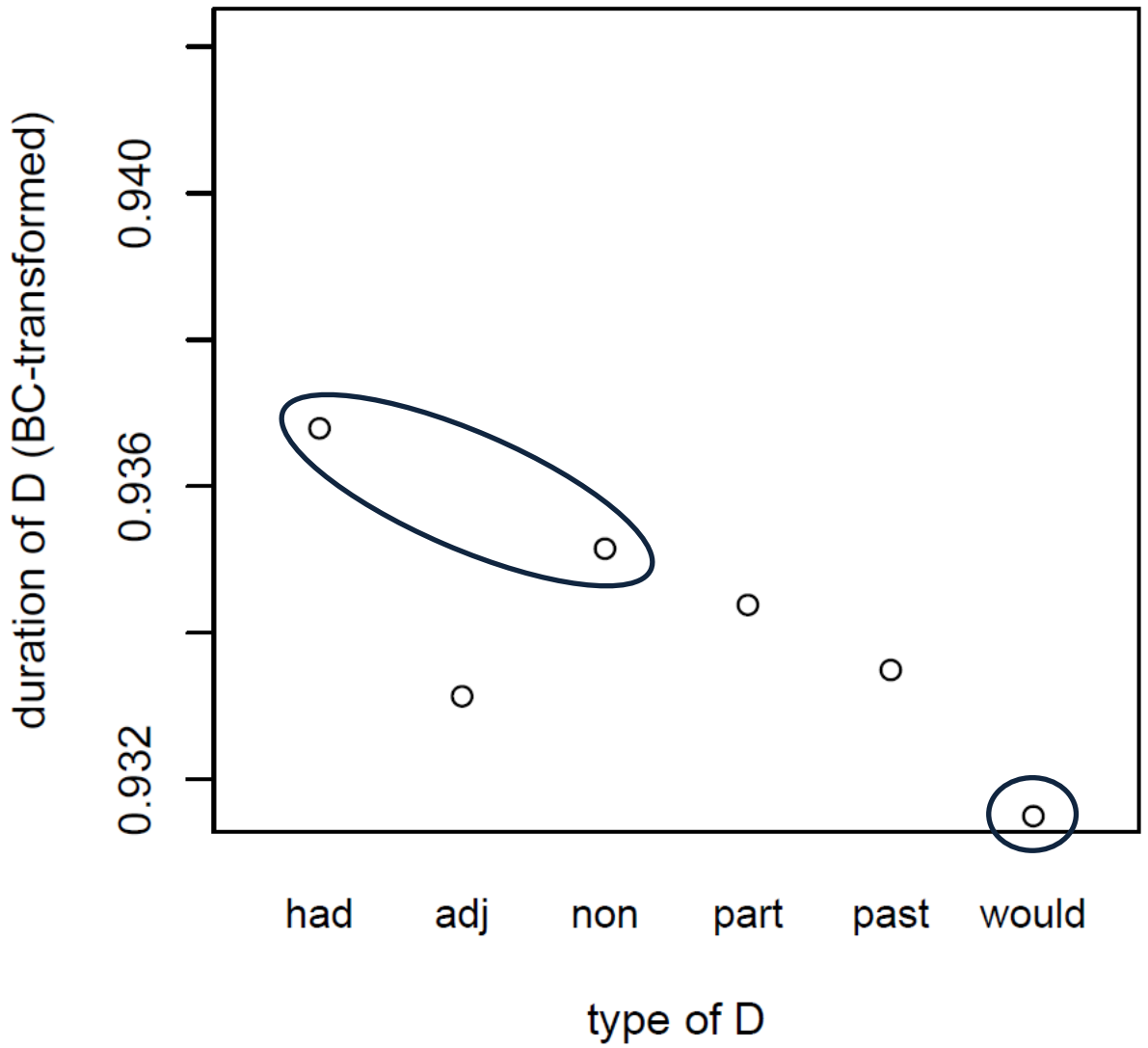
Results of reanalysis (LMER)

- No effect of morphemic status
- Effects of sound, pair, conditional transitional probablity, frequency

/d/: our data & analysis

- /t/ and /d/ (henceforth ‘D‘)
- Verbal -*ed*, adjectival -*ed*, clitics of *had, would*, non-morphemic final D; N = 380, 41-120 per category
- Predict DURATION of complete obstruction of D on the basis of TYPE of D
- **covariates** (selection)
  voicing
  item frequency
  speech rate (local, non-local)
  phonetic environment
  presence/absence of release/aspiration
  …

D: effect of TYPE OF D



D: summary

- Some non-morphemic sounds differ from morphemic sounds in duration.
- Different homophonous affixes differ in duration amongst each other.

General discussion

- Traditional analyses of English S and D morphemes do not cover or predict the acoustic differences found.

- The acoustic differences cannot be accounted for by purely phonetic processes (covariates are controlled).

- Phonetic detail must have some place in the description of the formal aspects of the morphemes involved.

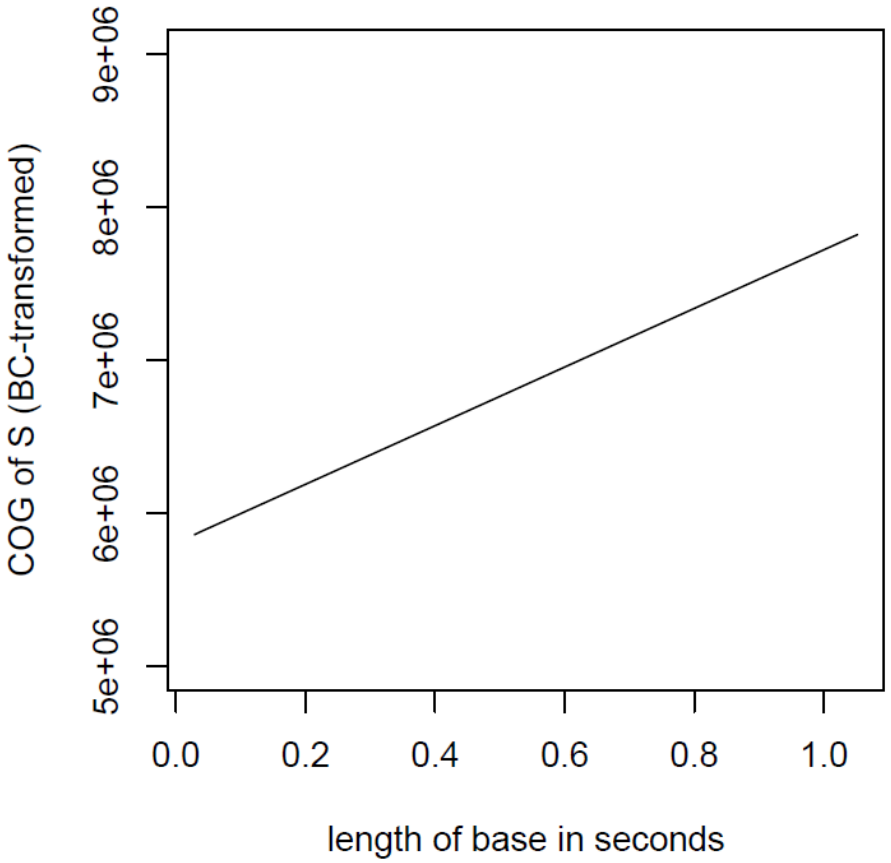
- Unclear implications for linguistic and psycholinguistic models

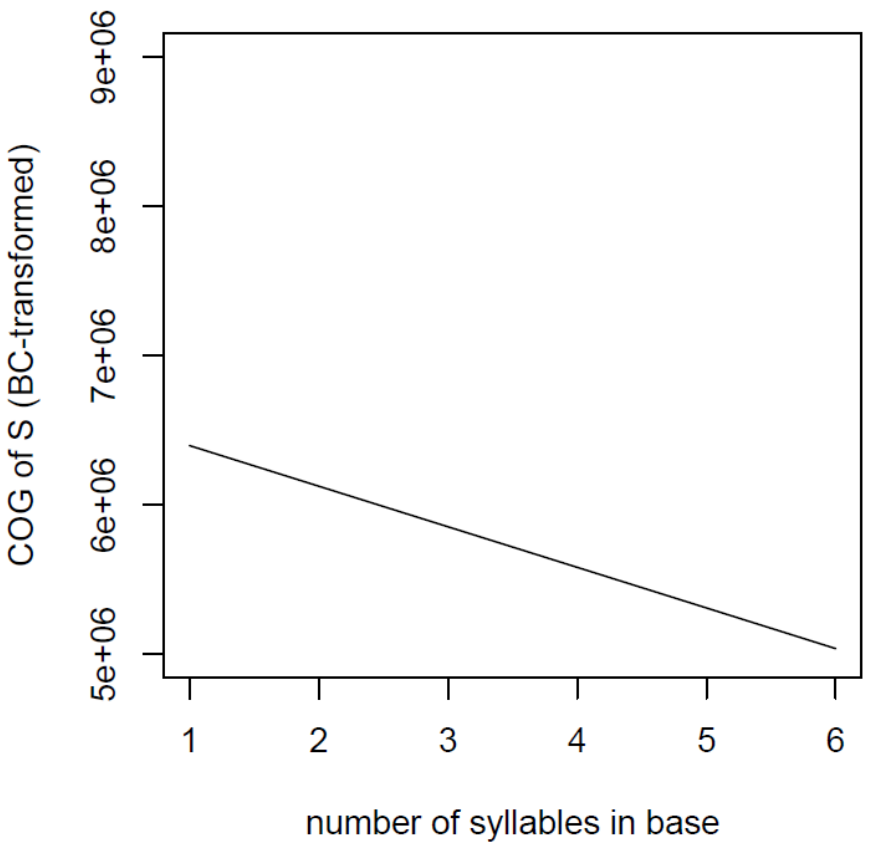
Future plans

- Replicate the observed production effects
- Test the differences in perception
- Develop new models of phonology-morphology interaction
- Have fun with the data

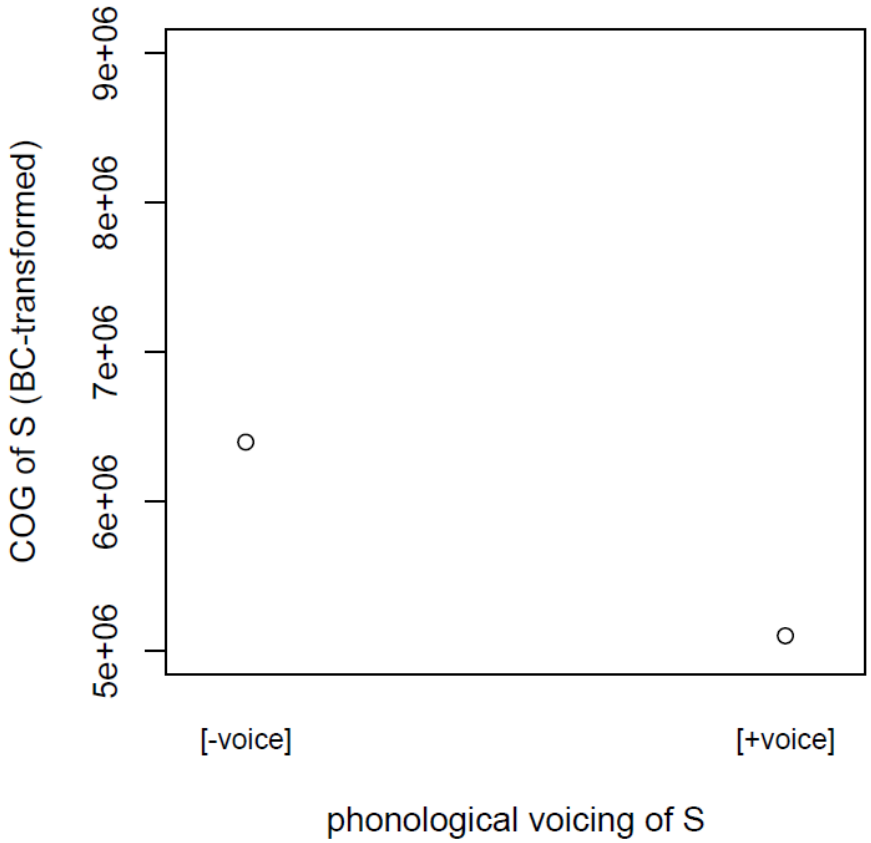
Thank you very much for your attention!

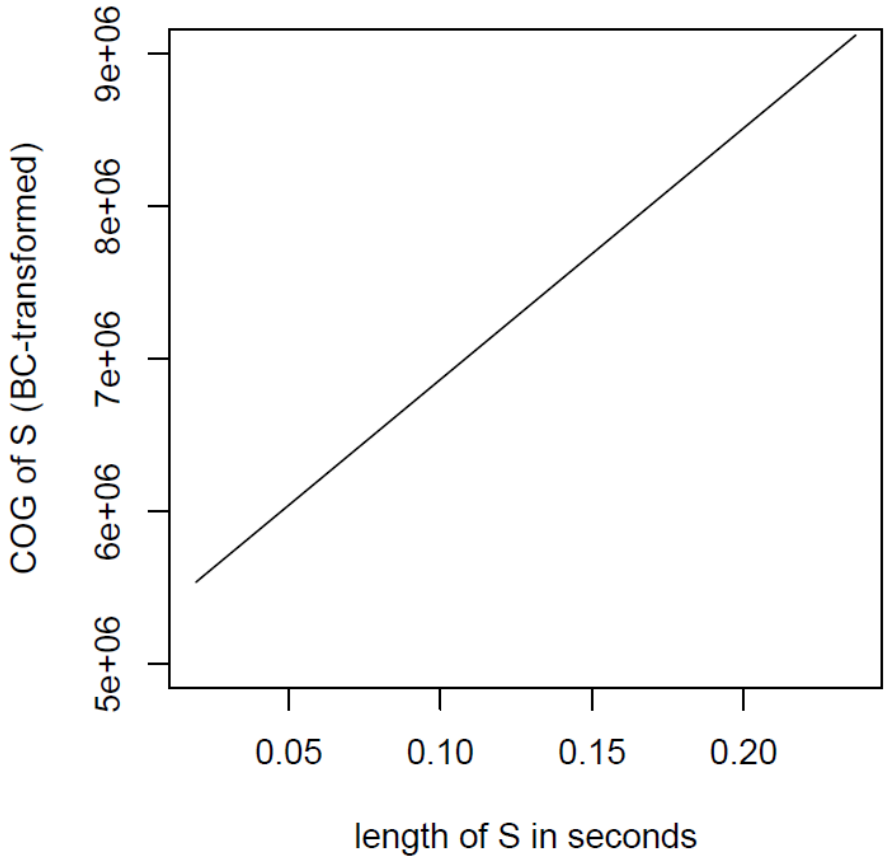
S COG: effect of covariates



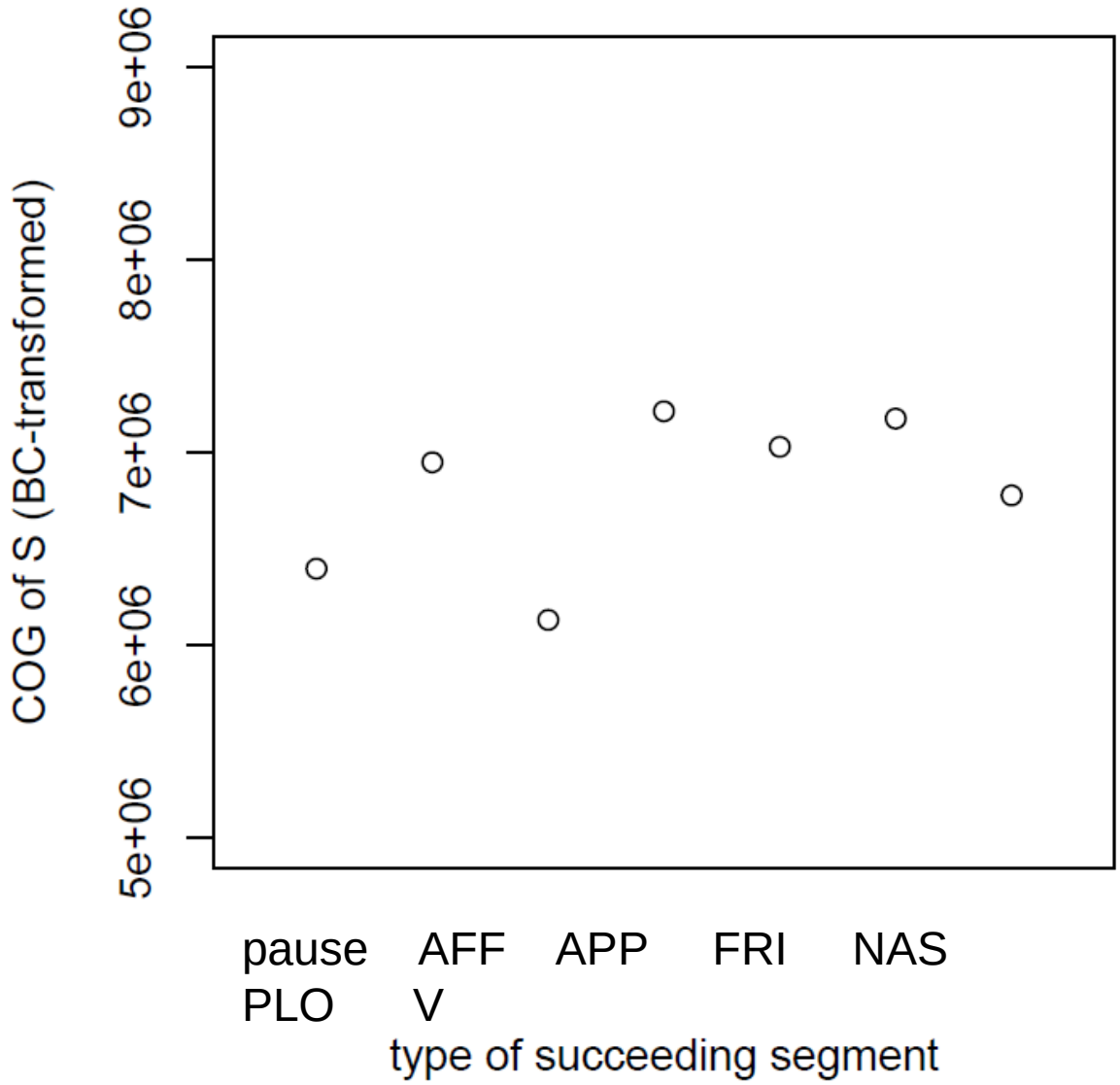


S COG: effect of covariates

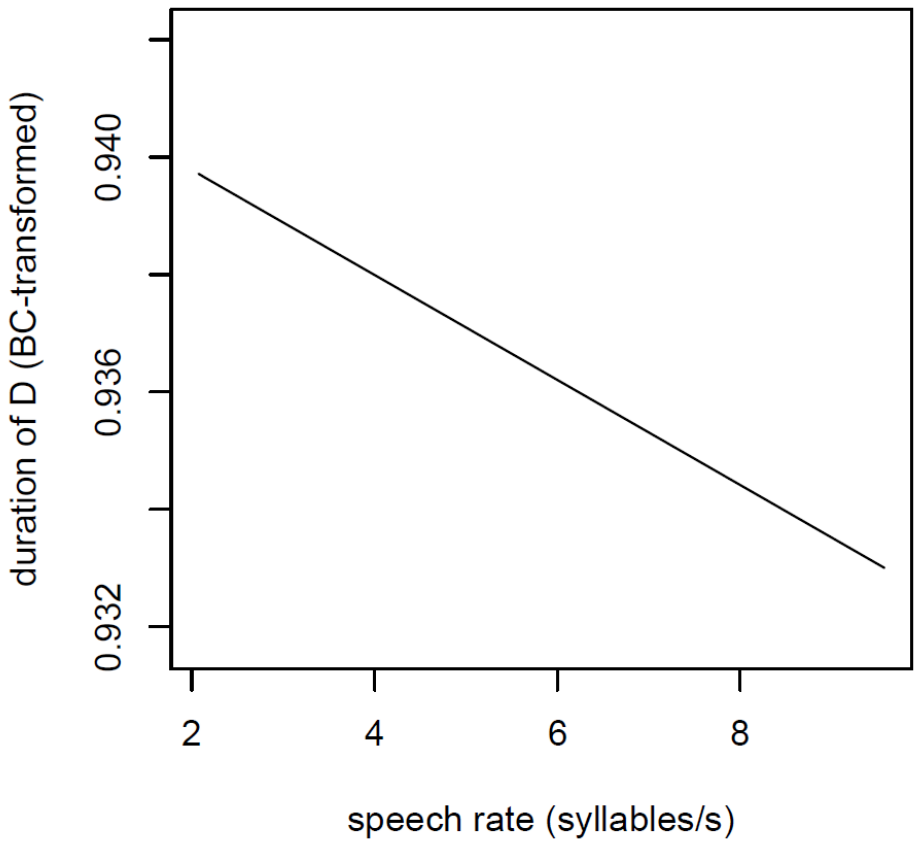


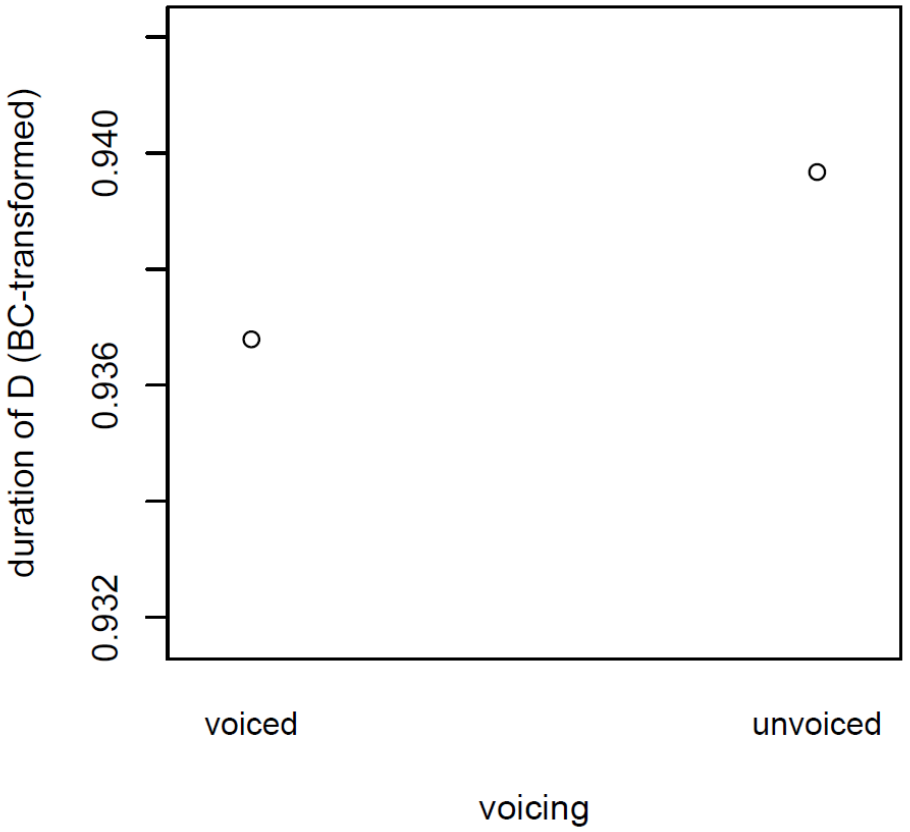


S COG: effect of covariates

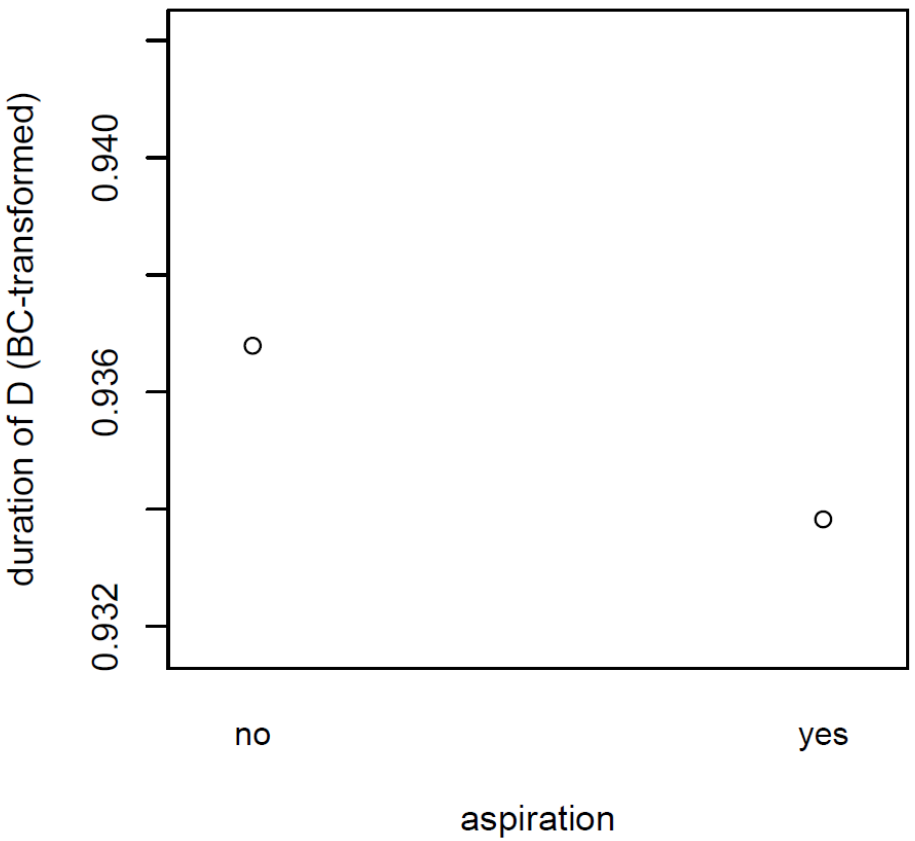


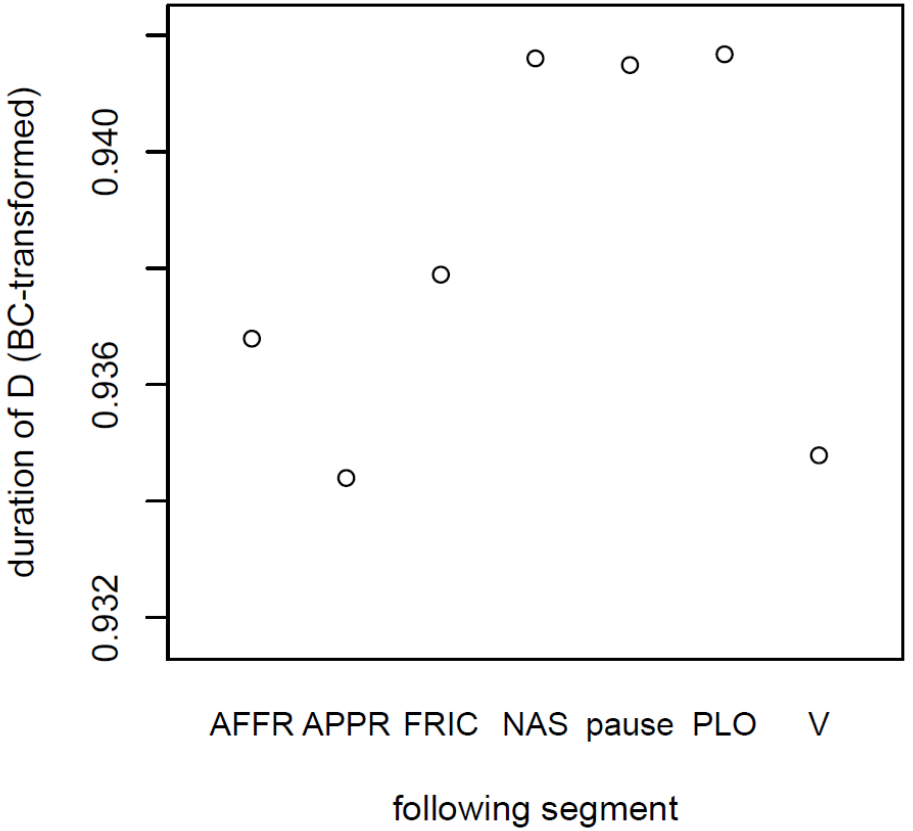
D: effect of covariates



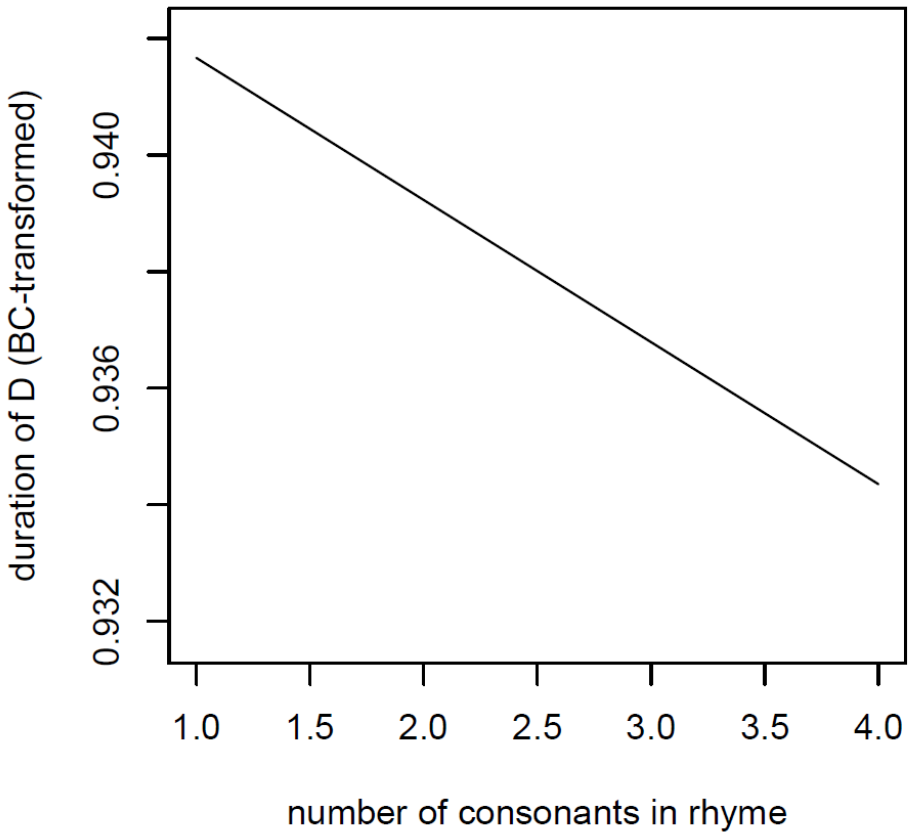


D: effect of covariates





D: effect of covariates



ADJECTIVE 89
 attr 42 --> all unique items
 pred 47 --> roughly same number as attr

HAD 41 --> all there is in Buckeye

VERB 120
 participle 40 --> roughly same number as others
 past 42 --> roughly same number as others
 passive 38 --> roughly same number as others

WOULD 57 --> all unique items

NON-MORPHEMIC ~80-120 --> classes b/c V/A in data + N as open class
 verb ~40 --> roughly same number as others
 noun ~40 --> roughly same number as others
 adjective ~40 --> roughly same number as others