What affects variation in the phonetics of NNN compounds?

Looking at the impact of morphological structure and more linguistic factors

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What affects variation?

speechrate

> higher speechrate leads to shorter duration/more segment reduction

number of phonological segments

> more phonological segments lead to longer durations

accentuation

> accented units have longer durations
> (Turk & Sawusch 1996, de Jong 2004, Kunter 2011)

lexical frequency

> more frequent units have shorter durations/are more prone to segment reduction
> (Pluymaekers et al. 2005, Gahl 2008, Bell et al. 2009)

What affects variation?

prosodic boundary strength

> boundaries at higher prosodic domains, i.e. intonation phrase (IP) or prosodic utterance (U), affect durations of units closest to the boundary
>
> > (Turk & Shattuck-Hufnagel 2000, Turk & Shattuck-Hufnagel 2007, Bergmann 2017)

morphological boundary strength

> units at weaker boundaries are more prone to segment reduction than units at stronger boundaries,
>
> units at weaker boundaries have shorter durations than units at stronger boundaries
>
> > (Lehiste 1972, Sproat & Fujimura 1993, Kunter & Plag 2016)

What affects variation?

prosodic boundary strength

boundaries at higher prosodic domains, i.e. intonation
phrase (IP) or prosodic utterance (U), affect durations of units closest
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(Turk & Shattuck-Hufnagel 2000, Turk & Shattuck-Hufnagel 2007,
Bergmann 2017)

morphological boundary strength

units at weaker boundaries are more prone to segment
reduction than units at stronger boundaries,

units at weaker boundaries have shorter durations than units at
stronger boundaries
(Lehiste 1972, Sproat & Fujimura 1993, Kunter & Plag 2016)

→ Embedded Reduction Hypothesis

Embedded Reduction Hypothesis (ERH)

In a complex word [X Y] Z,

the inner boundary between X and Y is more prone to phonetic reduction

than the outer boundary between Y and Z.

Morphological structure of NNN

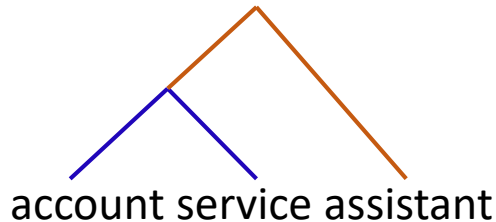LEFT-BRANCHING

[account$_{N1}$ service$_{N2}$] assistant$_{N3}$

RIGHT-BRANCHING

guest$_{N1}$ [account$_{N2}$ service$_{N3}$]

Morphological structure of NNN
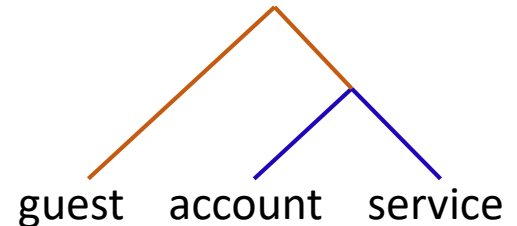
LEFT-BRANCHING

[account$_{N1}$ service$_{N2}$] assistant$_{N3}$

RIGHT-BRANCHING

guest$_{N1}$ [account$_{N2}$ service$_{N3}$]

account service assistant

guest account service

embedded constituents   free constituent

free constituent   embedded constituents

Predictions for NNN constituents

speechrate

> higher speechrate leads to shorter constituent durations

> higher speechrate leads to more segment reduction

number of phonological segments

> more phonological segments lead to longer constituent durations

accentuation

> accented constituents have longer durations

lexical frequency

> more frequent constituents and pairs of constituents have shorter durations

Predictions for NNN constituents

morphological boundary strength

→ ERH tested by Kunter & Plag (2016) for NNN compounds

ERH:

In a complex word [account service] assistant,

the inner boundary between account and service is more prone to phonetic reduction

than the outer boundary between service and assistant.

Predictions for NNN constituents

morphological boundary strength

→ ERH tested by Kunter & Plag (2016) for NNN compounds

ERH:

In a complex word guest [account service],

the inner boundary between account and service is more prone to phonetic reduction

than the outer boundary between guest and account.

Predictions for NNN constituents

morphological boundary strength

LEFT-BRANCHING   RIGHT-BRANCHING

[account$_{N1}$ service$_{N2}$] assistant$_{N3}$ guest$_{N1}$ [account$_{N2}$ service$_{N3}$]

The embedded constituents are relatively short.

The free constituent is relatively long.

This effect is independent of branching direction.

Predictions for NNN constituents

morphological boundary strength

LEFT-BRANCHING

RIGHT-BRANCHING

[account$_{N1}$ service$_{N2}$] assistant$_{N3}$

guest$_{N1}$ [account$_{N2}$ service$_{N3}$]

There is more segment reduction at the inner boundary (embedded compound)

than at the outer boundary (embedded + free constituent).

This effect is independent of branching direction.

Previous findings

Kunter & Plag (2016)

- experimental data (different purpose)

- significant interaction: CONSTITUENT * BRANCHING * BIGRAM FREQUENCY

  → in N_1 N_2 N_3 : N1N2 freq., N2N3 freq.

Schebesta & Kunter (in prep)

- corpus data

- significant interaction: CONSTITUENT * BRANCHING * BIGRAM FREQUENCY

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Previous findings

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Experiment 1

isolate bigram frequencies and branching direction

→ what does branching direction alone do?

constituent duration

plosive deletion (constituent boundaries)

Experiment 1

Data

[guest account] service   guest [account service]

[account service] assistant   account [service assistant]

Data

[guest account] service   **guest [account service]**

[account service] assistant   account [service assistant]

reading task:

"The service for accounts is installed for guests.

*The **guest account service** makes their stay more comfortable."*

Data

[guest account] service   **guest [account service]**

[account service] assistant   account [service assistant]

consonant sequences: nasal/fricative + PLOSIVE + fricative/nasal

(nts, ntf, stn, stm, ftn, ftm)

all bigram frequencies < 20 (COCA)

Four conditions: constituent duration

W1   W2

L1: [guest account] service

1. N3 is longest in L1 and L2.

W1   W2

L2: [account service] assistant

W1   W2

R1: guest [account service]

W1   W2

R2: account [service assistant]

Four conditions: constituent duration

W1   W2

L1: [guest account] service

    W1   W2

L2: [account service] assistant

      W1   W2

R1: guest [account service]

    W1   W2

R2: account [service assistant]

1. N3 is longest in L1 and L2.

2. N1 is longest in R1 and R2.

Four conditions: reduction

W1   W2

L1: [guest account] service

W1   W2

L2: [account service] assistant

W1   W2

R1: guest [account service]

W1   W2

R2: account [service assistant]

3. There is less plosive deletion in **account service** in L1 (outer) than in L2 (inner).

Four conditions: reduction

W1   W2

L1: [guest account] service

W1   W2

L2: [account service] assistant

W1   W2

R1: guest [account service]

W1   W2

R2: account [service assistant]

3. There is less plosive deletion in **account service** in L1 (outer) than in L2 (inner).

4. There is more plosive deletion in **account service** in R1 (inner) than R2 (outer).

Four conditions: reduction

W1   W2

L1: [guest account] service

     W1   W2

L2: [account service] assistant

     W1   W2

R1: guest [account service]

     W1   W2

R2: account [service assistant]

3. There is less plosive deletion in **account service** in L1 (outer) than in L2 (inner).

4. There is more plosive deletion in **account service** in R1 (inner) than R2 (outer).

5. **account** is longest in R2 (outer), because it is the free constituent.

Four conditions: reduction

W1   W2

L1: [guest account] service

W1   W2

L2: [account service] assistant

W1   W2

R1: guest [account service]

W1   W2

R2: account [service assistant]

3. There is less plosive deletion in **account service** in L1 (outer) than in L2 (inner).

4. There is more plosive deletion in **account service** in R1 (inner) than R2 (outer).

5. **account** is longest in R2 (outer), because it is the free constituent.

6. **service** is longest in L1 (outer), because it is the free constituent.

Data

25 **account service** pairs in 4 conditions = 100 compounds per speaker

41 speakers of North American English

3819 NNN compounds

    (excluded items: misreadings, pauses, sound quality…)

left = 1913	right = 1895

Data collection at the *APhL* in Edmonton, thank you!

Model 1: constituent duration

statistical analysis: lmer modelling

dependent variable: constituent duration

central interaction: constituent number * branching

predictors: frequencies of each constituent
bigram frequencies N1N2, N2N3
pitch range
no. of phonological segments
local speechrate

random effect: speaker, constituent

Results: main effects
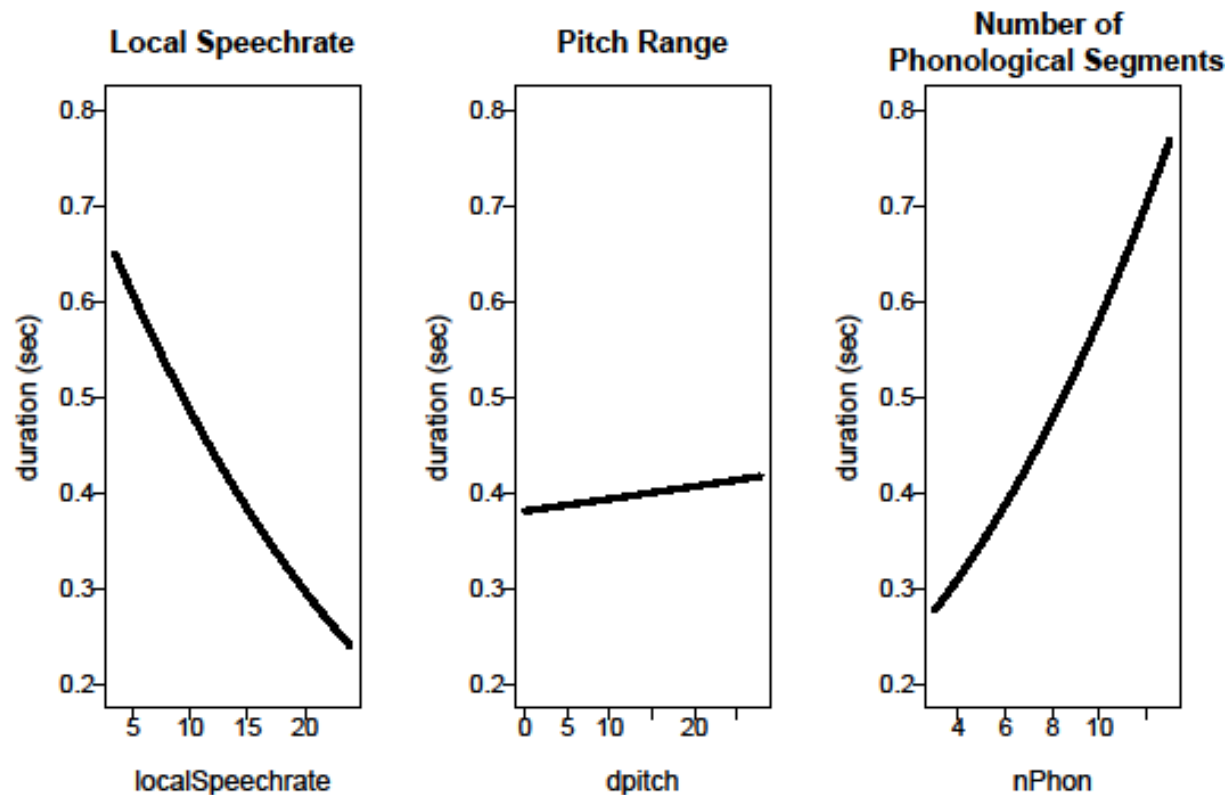
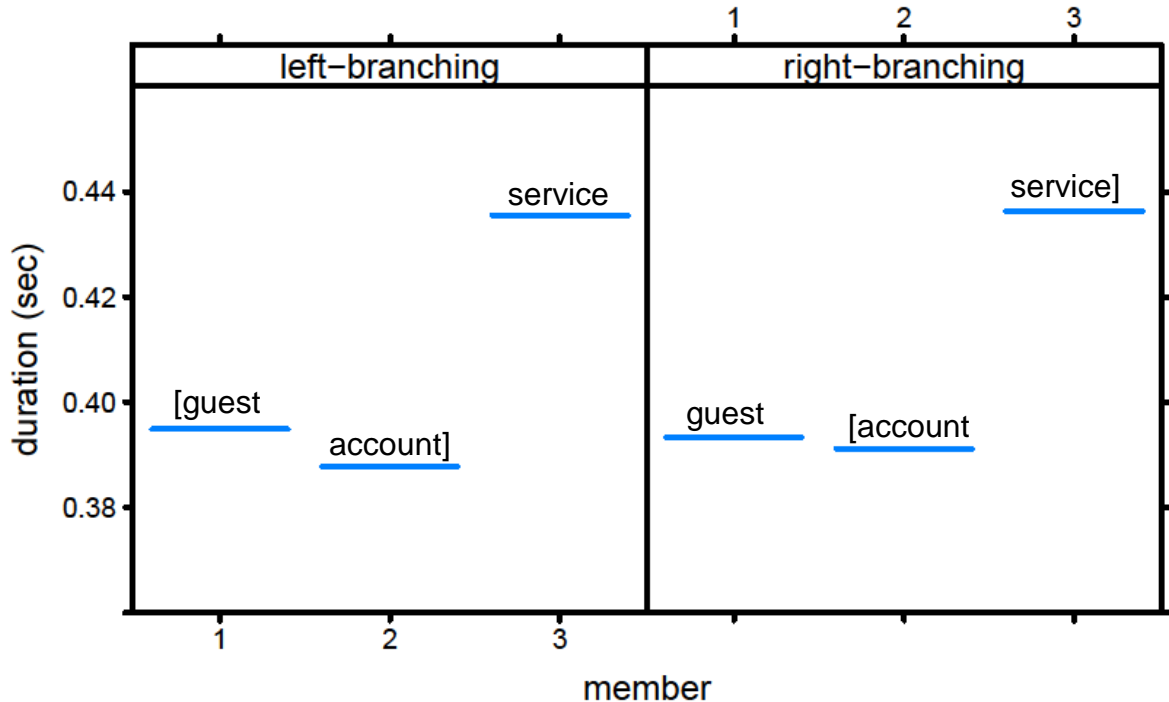# Results: constituent number * branching
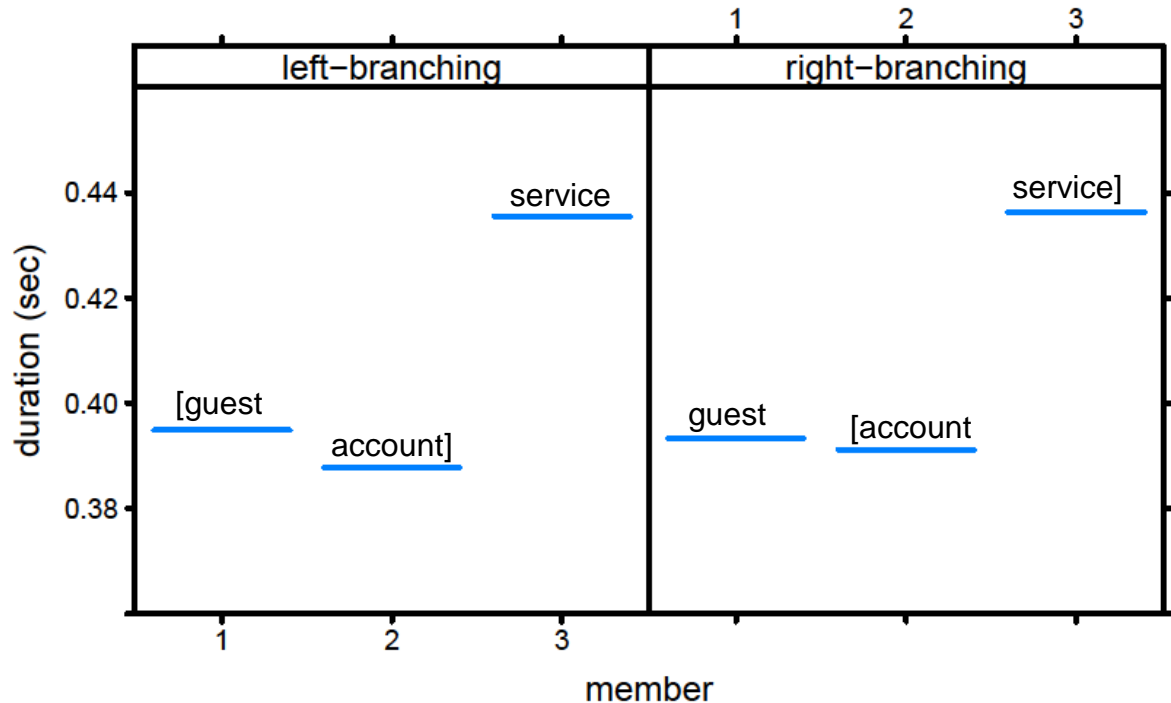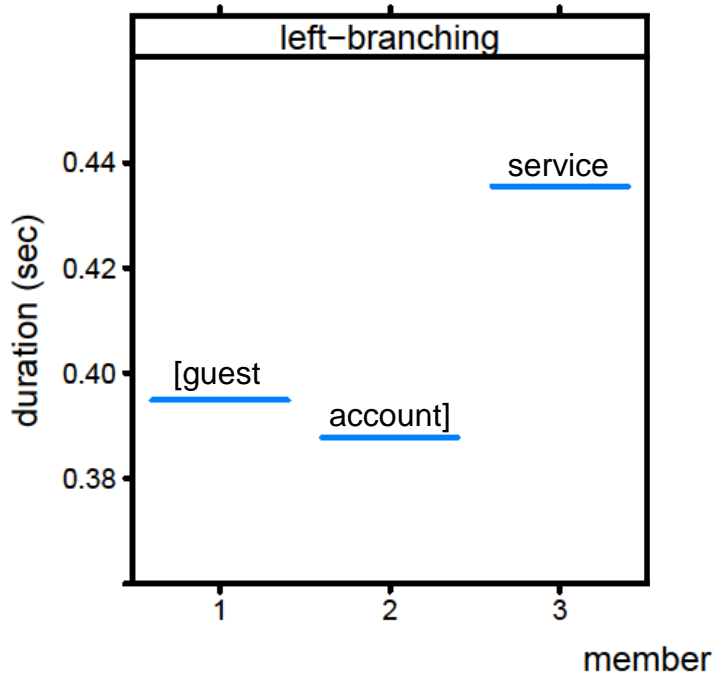
Results: constituent number * branching

Results: constituent number * branching
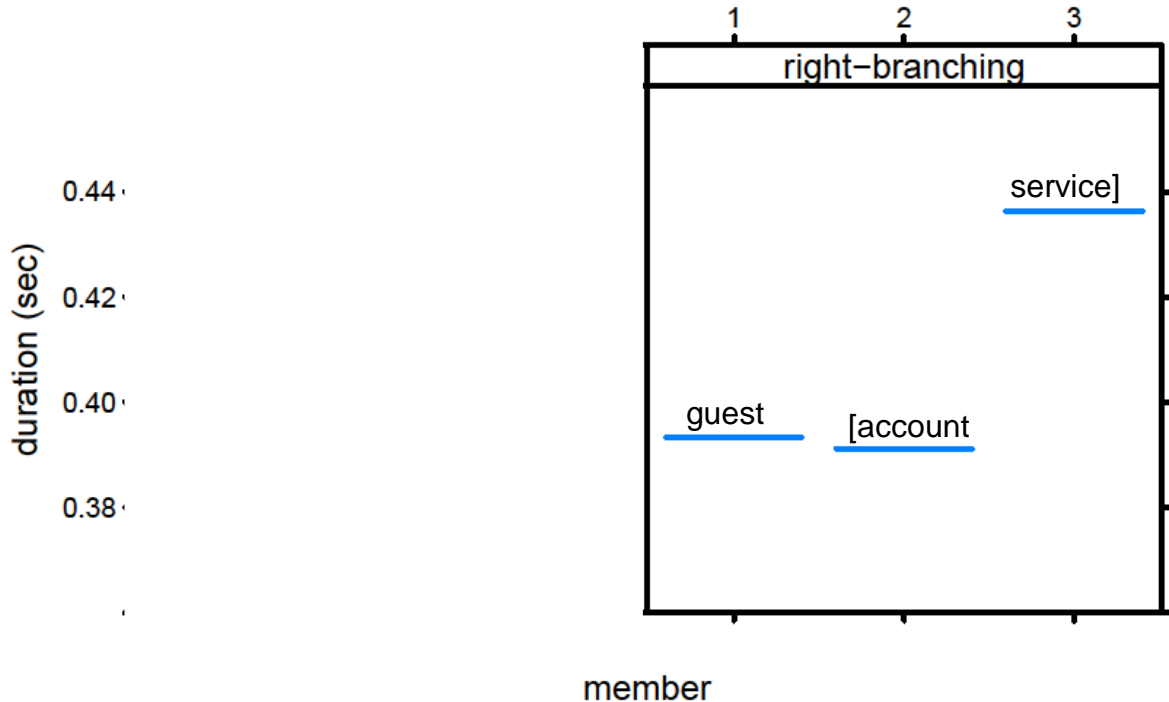
Results: constituent number * branching

Results: constituent durations

main effects: expected results

Prediction 1:

N3 is longest in L1 and L2.

confirmed.

Prediction 2:

N1 is longest in R1 and R2.

not confirmed.

Results: constituent durations

main effects: expected results

Predictions 1 + 2: (not) confirmed

N3 is always longest

left-branching: N2 < N1 < N3

right-branching: N2 ~ N1 < N3

→ no effect of embeddedness

→ word-final N3 lengthening in both branching directions

→ ERH not confirmed

Model 2: plosive deletion

statistical analysis: glmer modelling

dependent variable: plosive deletion
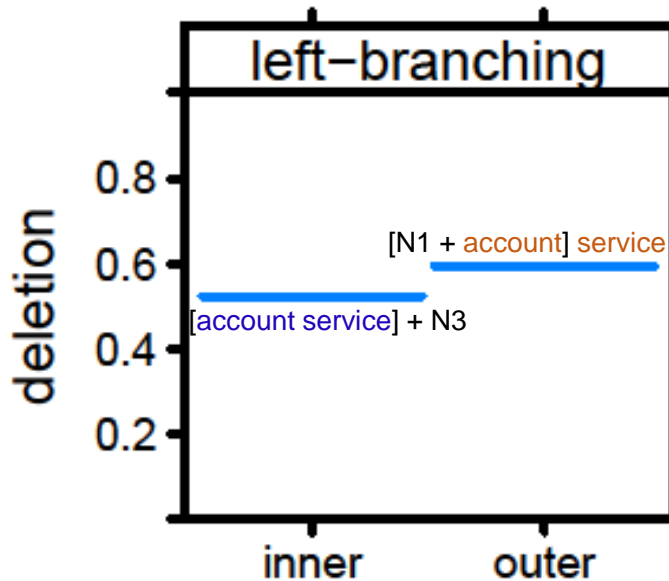
central interaction: boundary * branching

predictors: frequencies of each constituent
bigram frequencies N1N2, N2N3
no. of phonological segments
local speechrate
frequency of consonant sequence
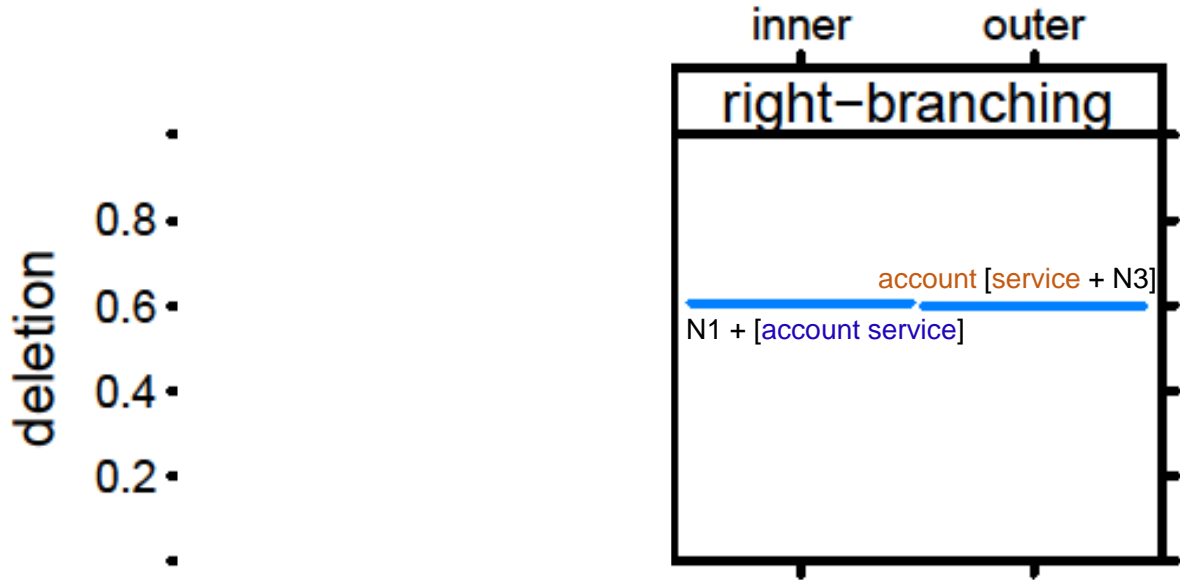
random effect: boundary|speaker, constituent
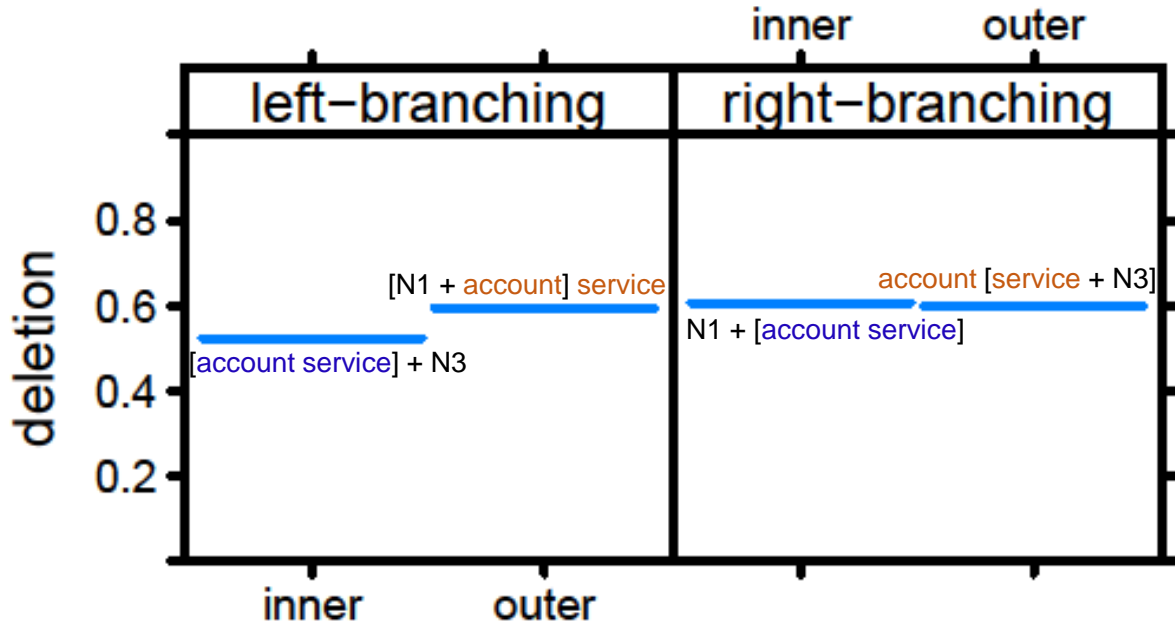
Results: boundary * branching
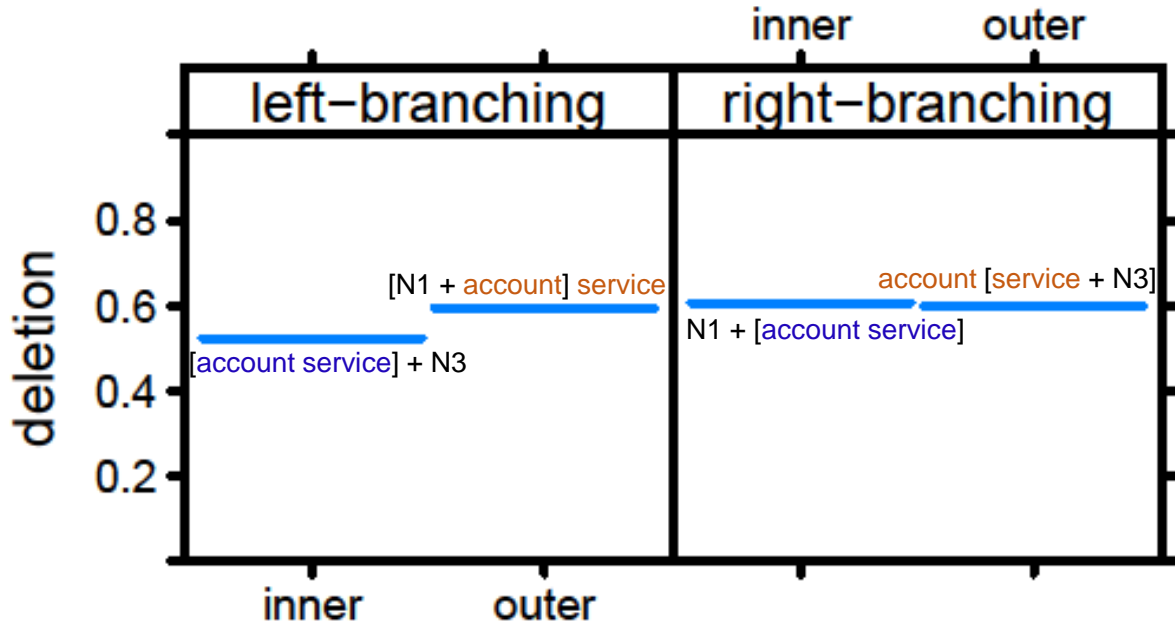
Results: boundary * branching

Results: boundary * branching

inner   outer

right–branching

account [service + N3]

N1 + [account service]

deletion

0.8
0.6
0.4
0.2

Results: boundary * branching

Results: plosive deletion

Prediction 3:
There is less plosive deletion in **account service**
in L1 (outer) than in L2 (inner).
        not confirmed.

Prediction 4:
There is more plosive deletion in **account service**
in R1 (inner) than R2 (outer).
        not confirmed.

significant main effects:

local speechrate, frequency of consonant sequence

Model 3: **account service** durations

statistical analysis: lmer modelling

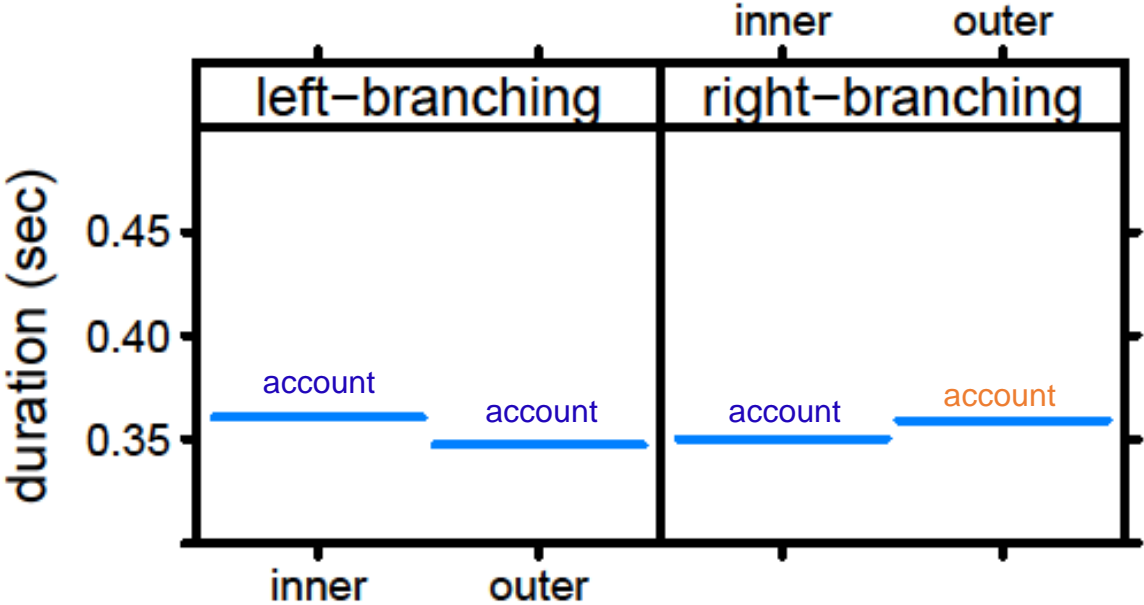dependent variable: **account/service** duration

central interaction: boundary * branching

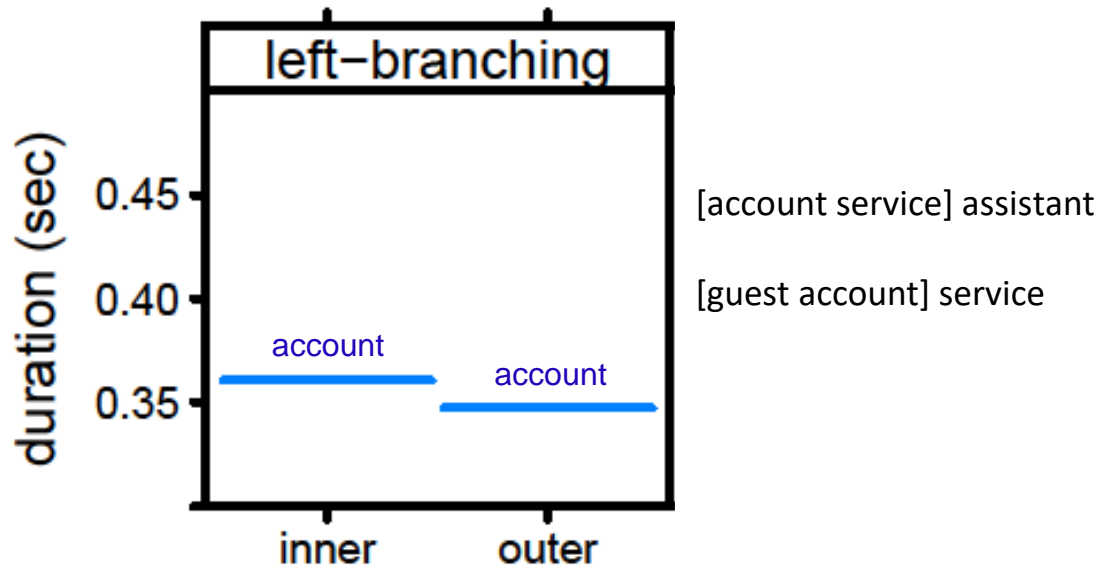predictors: frequencies of each constituent
                        bigram frequencies N1N2, N2N3
                        no. of phonological segments
                        local speechrate
                        frequency of consonant sequence
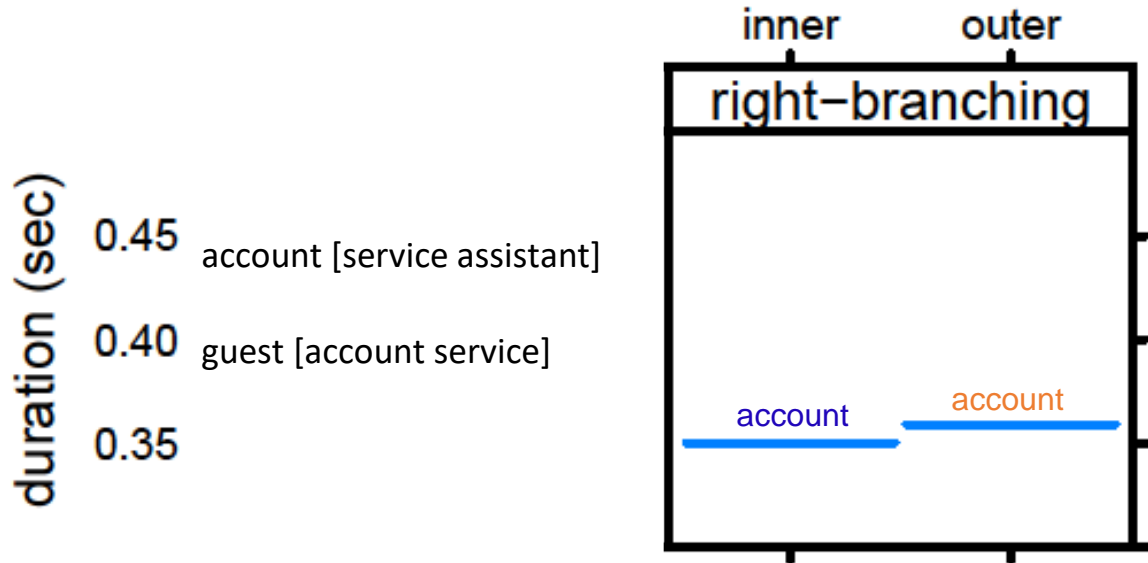   pitch range
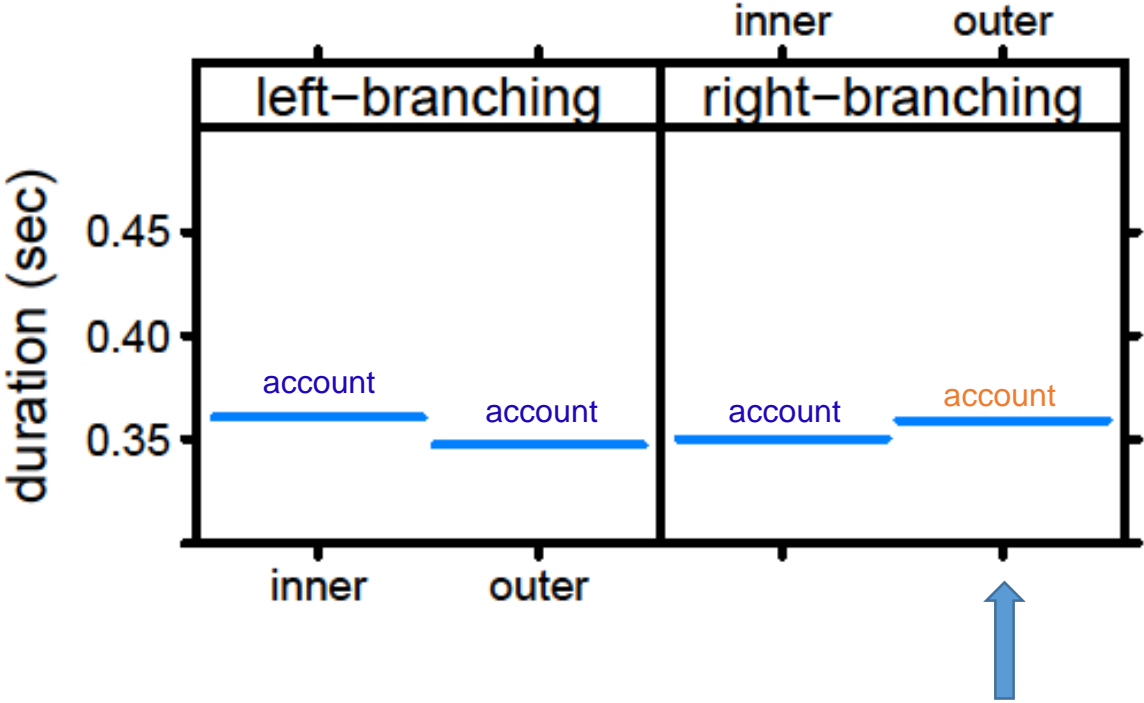
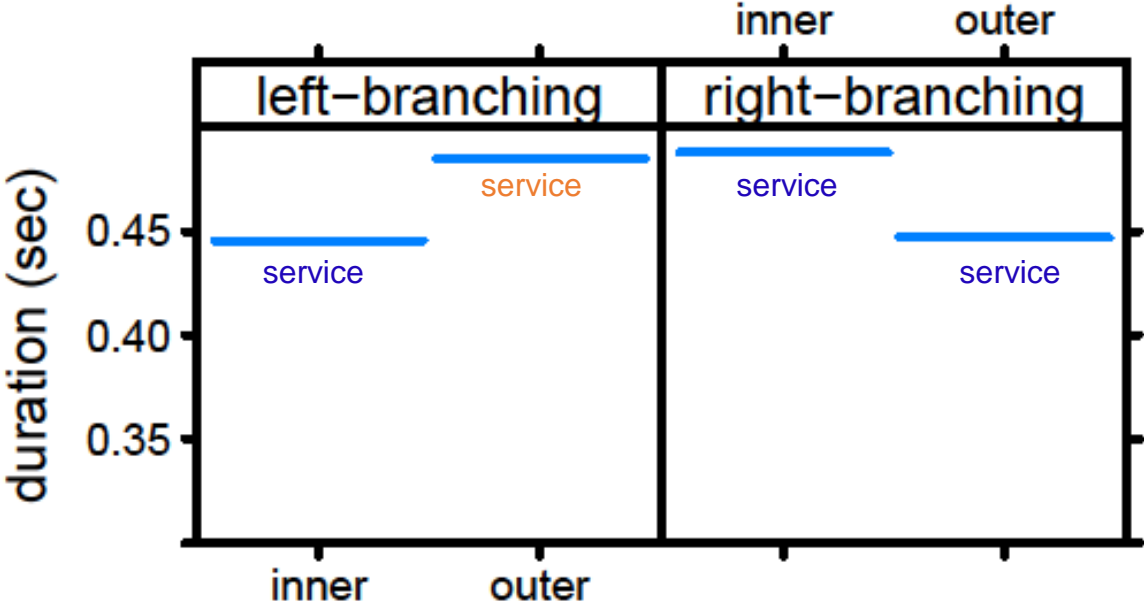random effect: boundary|speaker, constituent

Results: **account**

Results: **account**

[account service] assistant

[guest account] service

Results: account

duration (sec)

0.45   account [service assistant]

0.40   guest [account service]

0.35

Results: account

Results: **service**

Results: service

duration (sec)

0.45   account [service assistant]

0.40   guest [account service]

0.35

Results: service

[account service] assistant
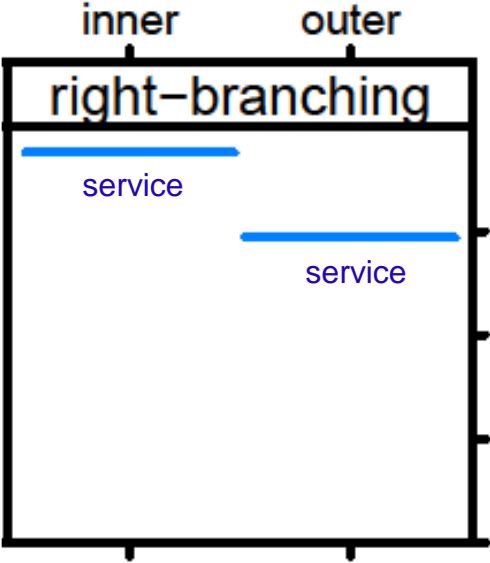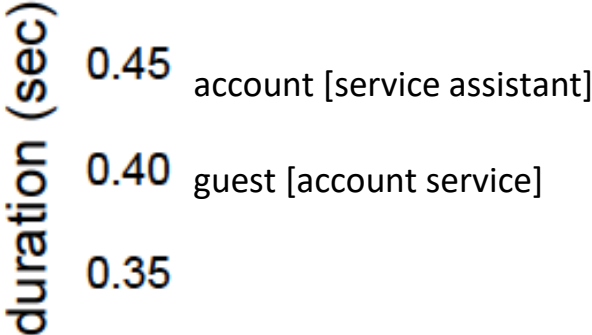
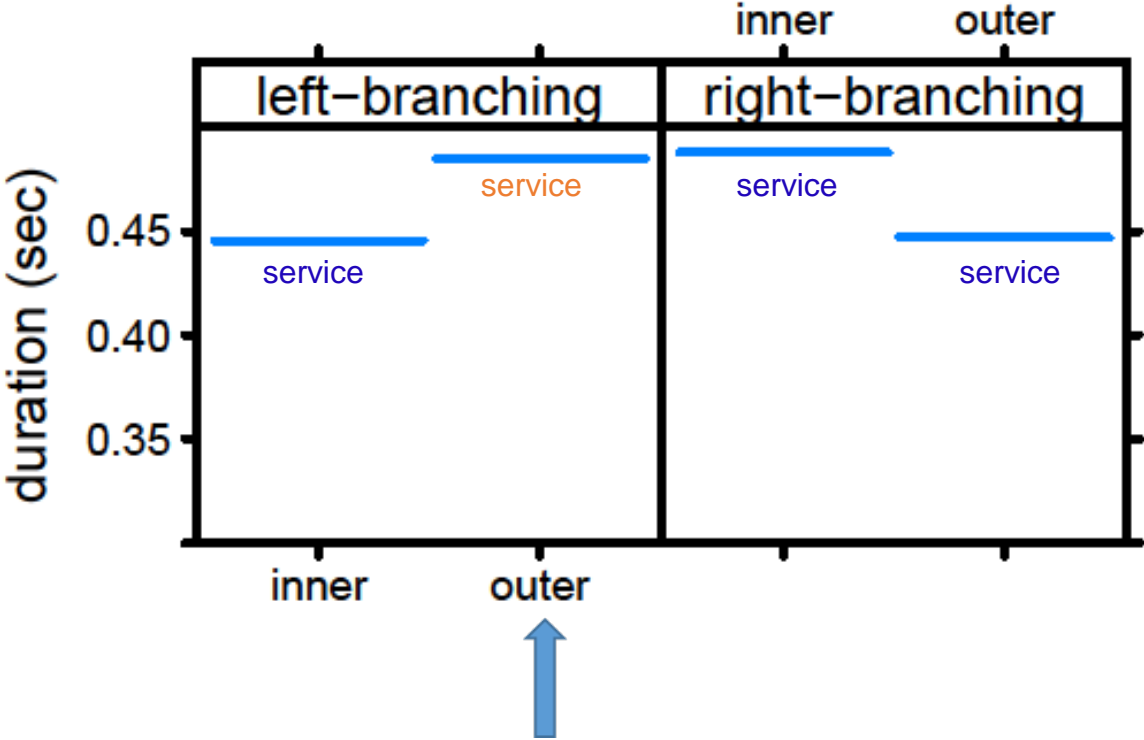[guest account] service
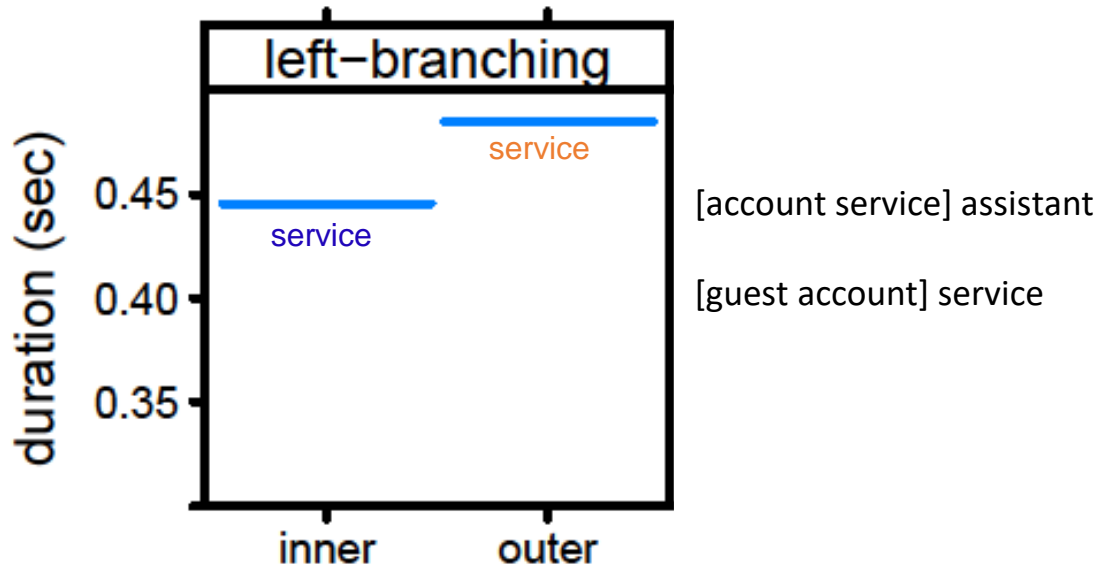
Results: service

Results: **account service**

Prediction 5:
account is longest in R2 (outer), because it is the free constituent.
    not confirmed.

Prediction 6:
service is longest in L1 (outer), because it is the free constituent.
    not confirmed.

significant main effects:

number of phon. segments, local speechrate, pitch range

Conclusion

branching direction does not play a role in reduction:

constituent duration: N1 + N2 < N3

plosive deletion: random deletion at both inner and outer
boundaries

account service duration: unexpected duration pattern

What's next?

Experiment II

NNN with varied bigram frequencies

(data collection Feb 2018)

Corpus Study II
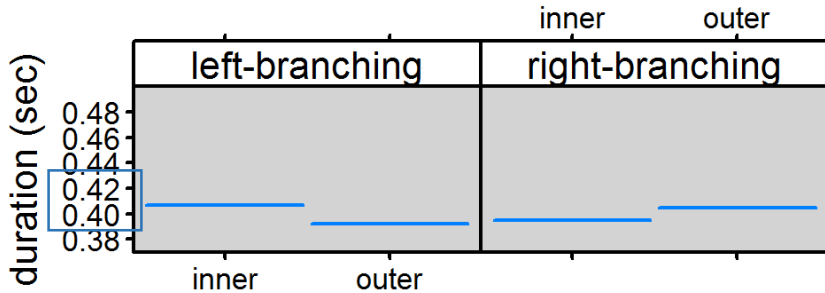
plosive deletion in NNN compounds

Thank you for listening!

References

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Pluymaekers, Mark, Mirjam Ernestus and R. Harald Baayen. 2005. Lexical frequency and acoustic reduction in Dutch. *The Journal of the Acoustical Society of America* 118 (4), 2561-2569.

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Turk, Alice E. and James R. Sawusch. 1996. The processing of duration and intensity cues to prominence. *The Journal of the Acoustical Society of America* 99 (6), 3782-3790.

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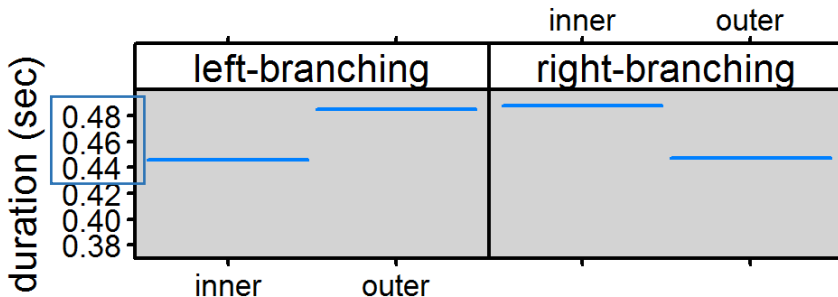
Remainings…

W1 Acoustic Duration

W1 is shorter than W2 no matter which position in the NNN
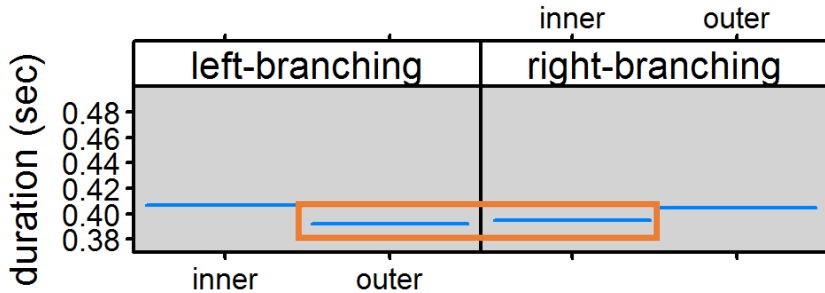
W2 Acoustic Duration

W1=N2 < W1=N1

< W2=N2 < W2=N3

Remainings...

W1 Acoustic Duration

W1 is shorter than W2
no matter which position
in the NNN

W2 Acoustic Duration

$W1=N2 < W1=N1$

$< W2=N2 < W2=N3$

Remainings...

W1 Acoustic Duration

W1 is shorter than W2 no matter which position in the NNN

W2 Acoustic Duration

W1=N2 < W1=N1

< W2=N2 < W2=N3

Remainings...

W1 Acoustic Duration

W1 is shorter than W2 no matter which position in the NNN

W1=N2 < W1=N1

< W2=N2 < W2=N3

W2 Acoustic Duration

Remainings...

W1 Acoustic Duration

W1 is shorter than W2 no matter which position in the NNN

W2 Acoustic Duration

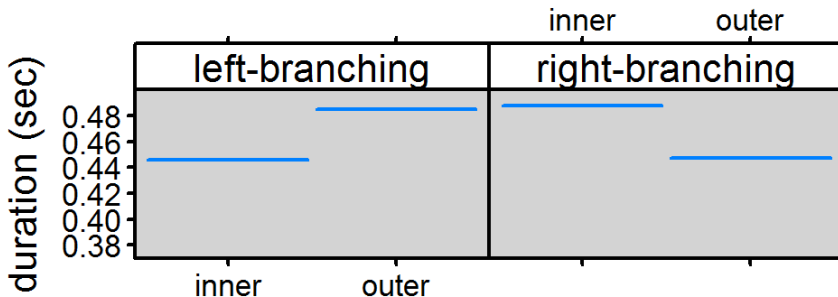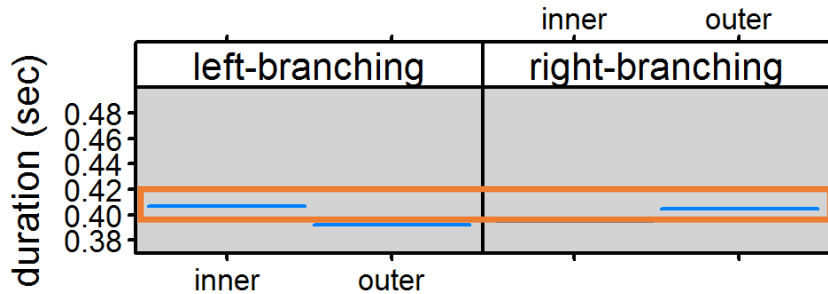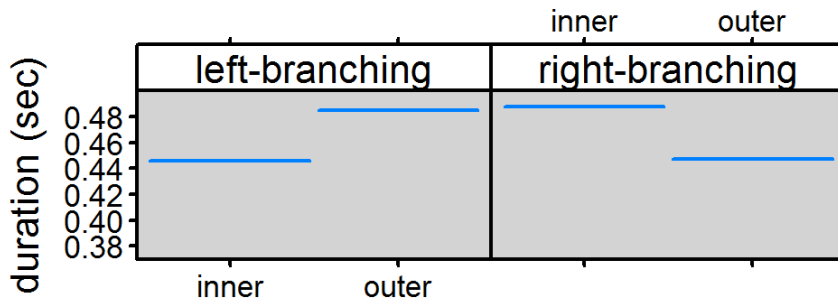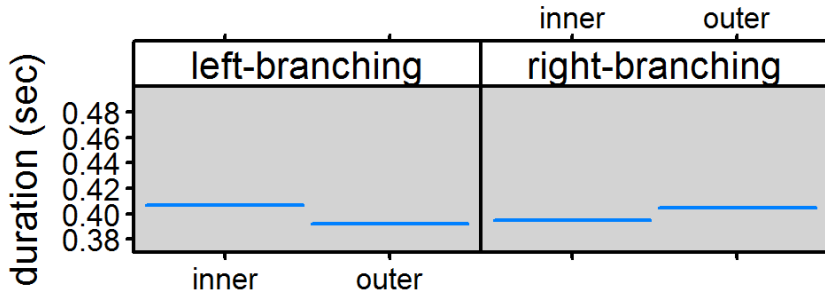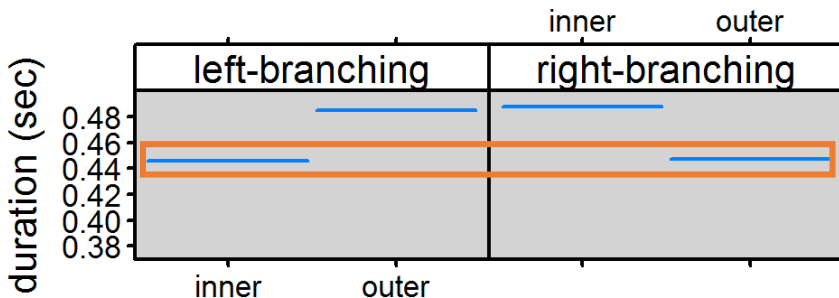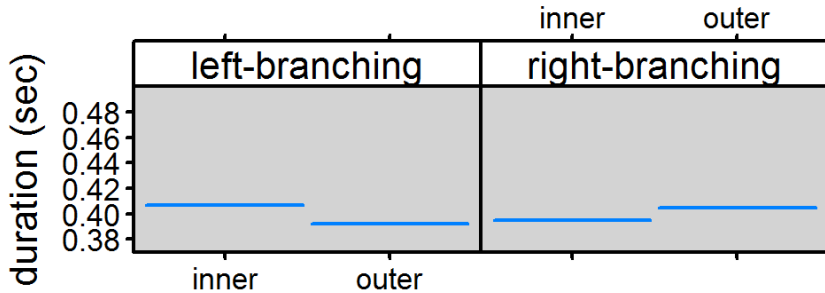
W1=N2 < W1=N1

< W2=N2 < W2=N3

Model 1: constituent duration

Fixed Effects	Estimate	Std. Error	df	t value	Pr(>|t|)	
(Intercept)	8.161e-01	8.138e-03	1.010e+02	100.277	<2e-16	***
member1	-2.042e-02	1.117e-03	1.125e+04	-18.273	<2e-16	***
member2	-2.414e-02	9.051e-04	1.137e+04	-26.672	<2e-16	***
branchingright-branching	3.561e-04	7.771e-04	1.129e+04	0.458	0.647	
localSpeechrate	-9.999e-03	1.420e-04	9.134e+03	-70.417	<2e-16	***
nPhon	2.193e-02	1.110e-03	8.700e+01	19.755	<2e-16	***
dpitch	6.762e-04	5.304e-05	1.134e+04	12.748	<2e-16	***
member1:branchingright-branching	-1.204e-03	1.098e-03	1.129e+04	-1.096	0.273	
member2:branchingright-branching	1.443e-03	1.098e-03	1.129e+04	1.313	0.189	

Model 2: plosive deletion

Fixed Effects	Estimate	Std. Error	z value	Pr (>|z|)	
(Intercept)	2.87589	0.48694	5.906	3.50e-09	***
boundaryouter	-0.29126	0.12461	-2.337	0.01942	*
branchingright-branching	-0.33864	0.12394	-2.732	0.00629	**
logN1N2Freq	0.27449	0.09380	2.927	0.00343	**
sequenceFreq532	-0.72034	0.46930	-1.535	0.12480	
sequenceFreq750	-0.76140	0.62854	-1.211	0.22575	
sequenceFreq2885	-0.59913	0.50882	-1.177	0.23900	
sequenceFreq3853	-0.90260	0.42118	-2.143	0.03211	*
sequenceFreq5189	-0.88079	0.40149	-2.194	0.02825	*
localSpeechrate	-0.16162	0.02317	-6.975	3.05e-12	***
boundaryouter:branchingright-branching	0.32361	0.19999	1.618	0.10564	

Model 3: **account** duration

Fixed Effects	Estimate	Std. Error	df	t value	Pr (>|t|)	
(Intercept)	9.416e-01	3.585e-03	2.600e+01	262.654	< 2e-16	***
boundaryouter	-2.110e-03	3.616e-04	3.718e+03	-5.835	5.83e-09	***
branchingright-branching	-1.659e-03	3.635e-04	3.720e+03	-4.562	5.22e-06	***
logN1N2Freq	1.631e-03	3.121e-04	3.231e+03	5.226	1.84e-07	***
localSpeechrate	-2.635e-03	6.404e-05	3.247e+03	-41.140	< 2e-16	***
nPhon	5.944e-03	4.702e-04	2.300e+01	12.641	6.57e-12	***
dpitch	1.429e-04	2.315e-05	3.780e+03	6.172	7.45e-10	***
boundaryouter:branchingright-branching	3.516e-03	6.032e-04	3.629e+03	5.829	6.06e-09	***

Model 3: **service** duration

Fixed Effects	Estimate	Std. Error	df	t value	Pr (>|t|)	
(Intercept)	4.534e-01	4.143e-02	1.700e+01	10.942	4.32e-09	***
boundaryouter	3.717e-02	2.339e-03	3.581e+03	15.889	< 2e-16	***
branchingright-branching	3.983e-02	2.351e-03	3.581e+03	16.943	< 2e-16	***
logN1N2Freq	1.235e-02	1.954e-03	3.302e+03	6.320	2.96e-10	***
logN2N3Freq	1.078e-02	1.692e-03	3.478e+03	6.370	2.14e-10	***
localSpeechrate	-2.332e-02	4.382e-04	2.118e+03	-53.210	< 2e-16	***
nPhon	4.913e-02	4.354e-03	1.600e+01	11.286	3.60e-09	***
sequenceFreq532	1.899e-03	4.108e-02	1.600e+01	0.046	0.9637	
sequenceFreq750	-5.069e-03	5.526e-02	1.600e+01	-0.092	0.9280	
sequenceFreq2885	1.044e-02	3.470e-02	1.700e+01	0.301	0.7673	
sequenceFreq3853	5.121e-02	3.672e-02	1.600e+01	1.395	0.1817	
sequencefreq5189	7.838e-02	3.461e-02	1.600e+01	2.264	0.0374	*
dpitch	1.315e-03	1.586e-04	3.607e+03	8.293	< 2e-16	***
boundaryouter:branchingright-branching	-7.535e-02	3.902e-03	3.584e+03	-19.314	< 2e-16	***