HEINRICH HEINE
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Lexical storage and morphological segmentability in speech production

New evidence from English derivational affixes

Simon David Stein
Ingo Plag

DFG Deutsche Forschungsgemeinschaft
FOR2373

Frequency and duration

Frequency and duration

Lexical frequency

How often does a word occur in a language?

Acoustic duration

How long do we pronounce linguistic units?

Frequency and duration

Lexical frequency

How often does a word occur in a language?

Acoustic duration

How long do we pronounce linguistic units?

Usual assumption:

The higher the frequency, the shorter the duration of linguistic units such as words, bases, and affixes.

Storage in the mental lexicon

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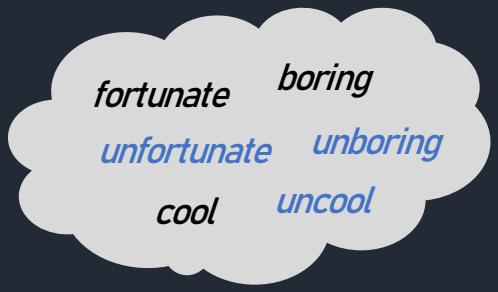
Whole-word storage



complex words are stored unanalyzed

Caselli et al. 2016, examples from Hay 2007: 40–41

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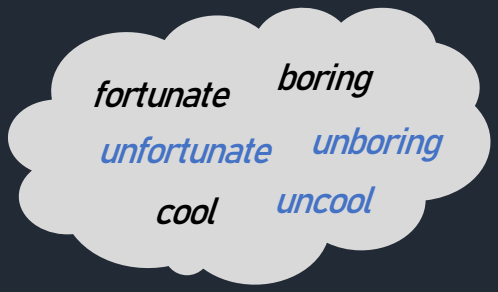

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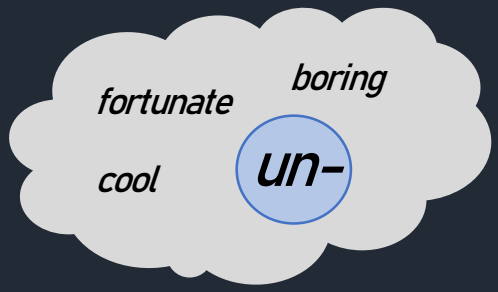
Compositional models



morphemes are stored separately

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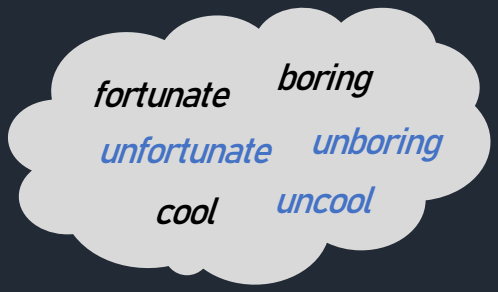

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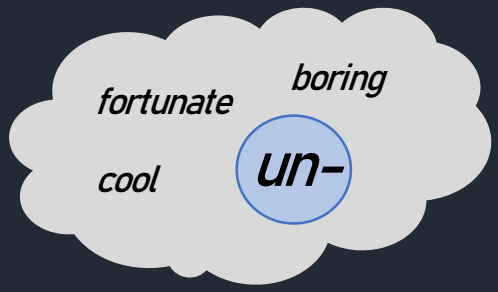

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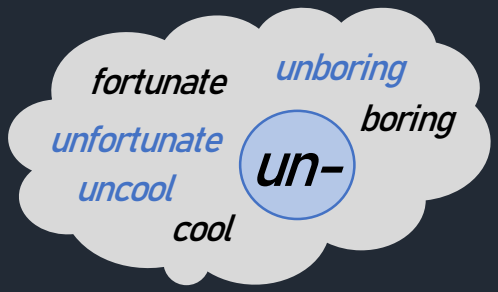

both morphemes and complex words are stored

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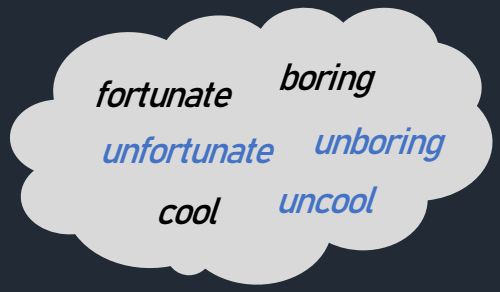

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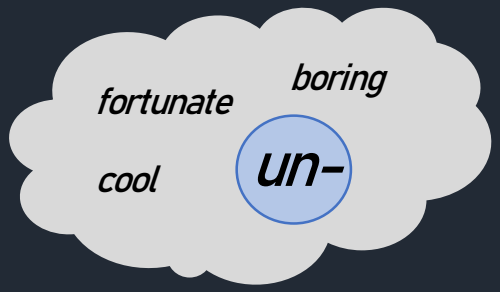

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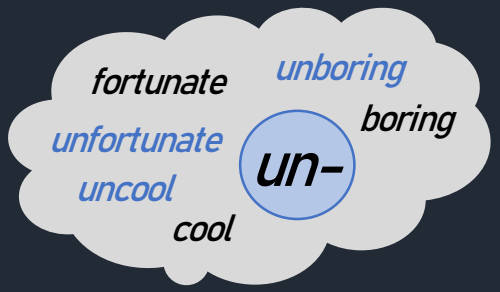

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Segmentability

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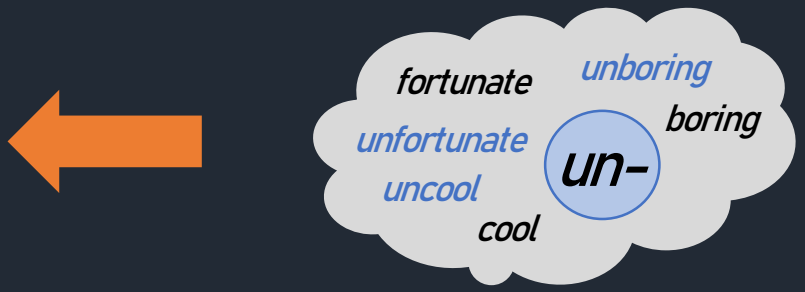

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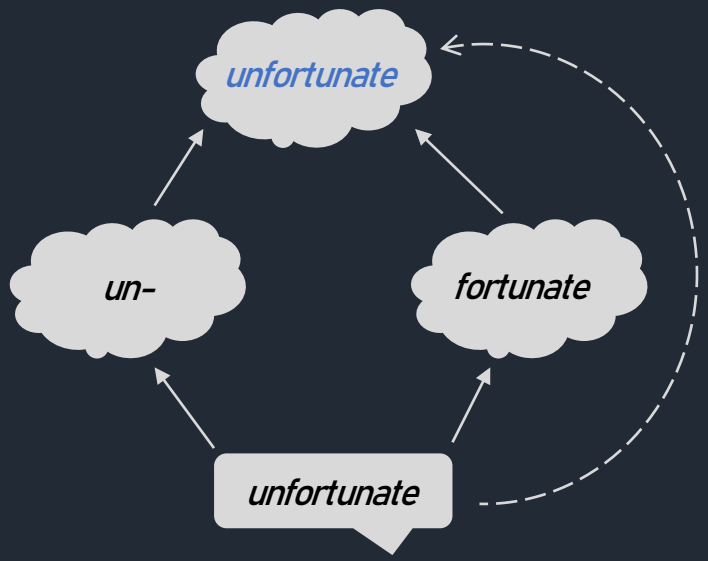

adapted from
Hay 2001: 1045

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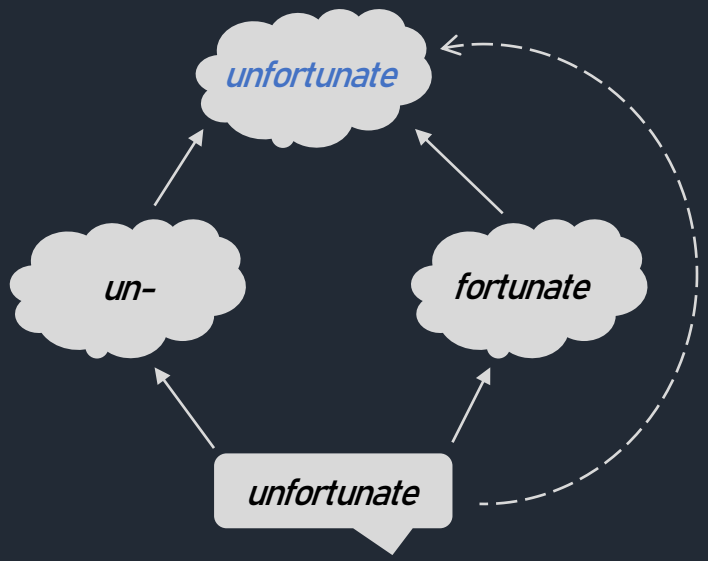

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Word	Frequency	Segmentability	Prediction
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unfortunate	6915		
boring	7483	high	longer duration
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Caselli et al. 2016, examples from Hay 2007: 40–41, frequencies from COCA, Davies 2008

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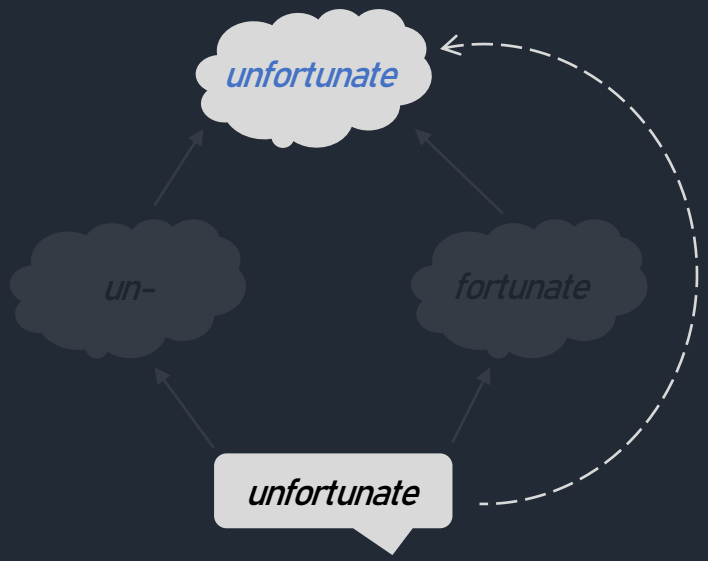

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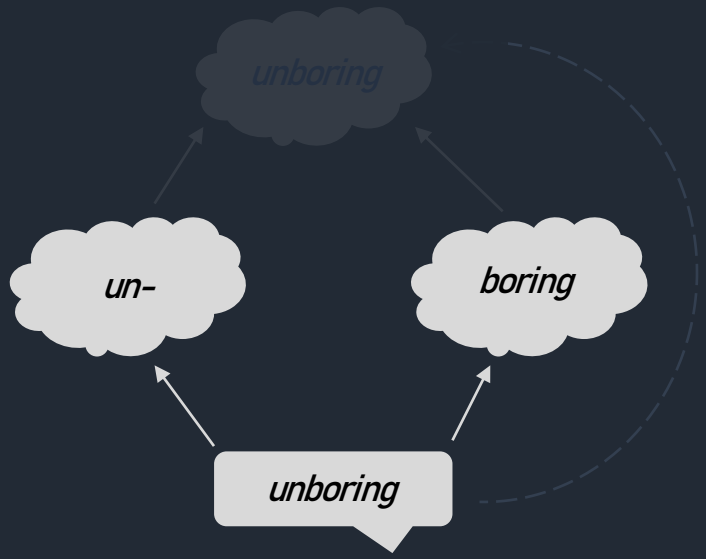

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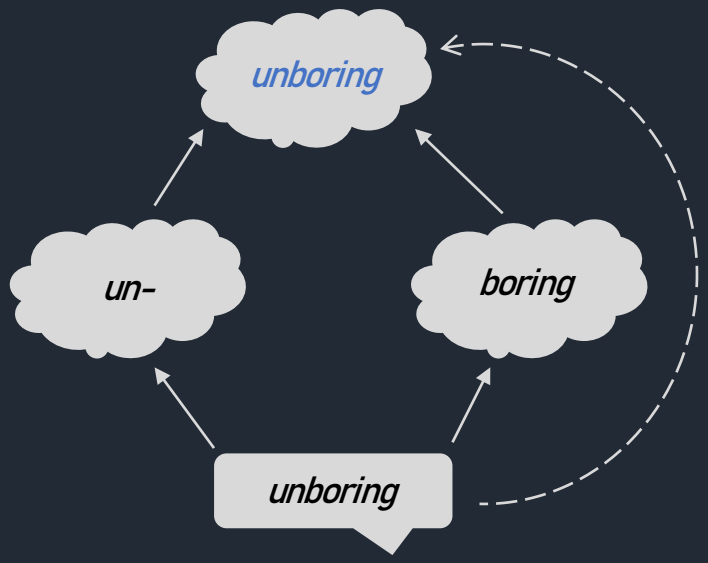

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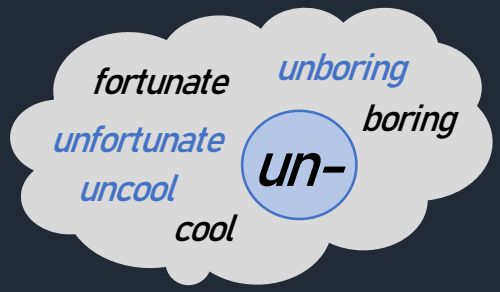

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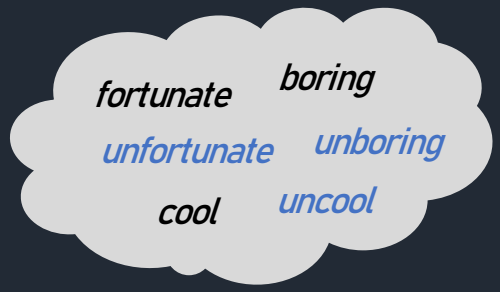

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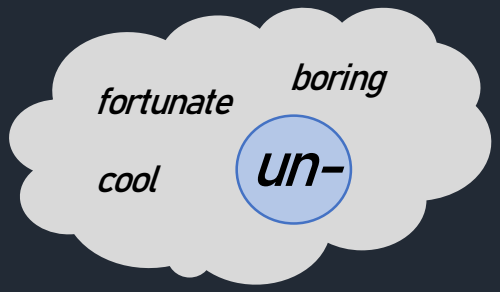

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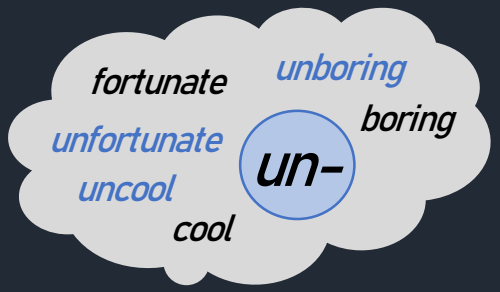

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Caselli et al. 2016

- inflectional suffixes *-ing*, *-ed*, and *-s*
- evidence for both whole-word storage and composition
  - higher base frequency → shorter word duration
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Contradictory evidence:
Why do the frequency measures sometimes show and sometimes not show effects?

Caselli et al. 2016, Hay 2003, 2007, Plag and Ben Hedia 2018

Present study

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Hypothesis 1

Higher word frequency → shorter duration

Present study

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Higher word frequency → shorter duration

Hypothesis 2

Higher base frequency → shorter duration

Present study

Hypothesis 1

Higher word frequency → shorter duration

Hypothesis 2

Higher base frequency → shorter duration

Hypothesis 3

Higher relative frequency → longer duration

≈ more segmentability

Present study

Hypothesis 1

Higher word frequency → shorter duration of word, base, and affix

Hypothesis 2

Higher base frequency → shorter duration of word, base, and affix

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Data and measurement

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Data collection

- AudioBNC
- Forced Alignment
- Praat textgrids
- manual cleaning of results

Coleman et al. 2012, Boersma and Weenik 2014

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Affixes	N
-ness	364
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- multiple linear regression in R using lm-function
- variable transformations
- trimming of datasets
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Covariates

- speech rate
- number of syllables
- biphone probability sum
- bigram frequency

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- separate models for durations and frequencies: 54 models

Coleman et al. 2012, Boersma and Weenik 2014, R Core Team 2017, Davies 2008, Vitevitch and Luce 2004

Frequency and segmentability effects

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affix	pre-		
duration	word	affix	base
word frequency			
base frequency			
relative frequency			

p < .001 expected direction

Frequency and segmentability effects

affix	pre-			-ness		
duration	word	affix	base	word	affix	base
word frequency						
base frequency						
relative frequency						

p < .001 expected direction

Frequency and segmentability effects

affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

p < .001 expected direction

p < .001 unexpected direction

Frequency and segmentability effects

affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

affix	-wise		
duration	word	affix	base
word frequency			
base frequency			
relative frequency			

	$p < .001$	expected direction
	$p < .001$	unexpected direction

Frequency and segmentability effects

affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
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affix	-wise			-less		
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word frequency									
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Are the differences related to ...

Results

Prefixes vs. suffixes

affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
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duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
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Are the differences related to ... the type of affix?

Results

Prefixes vs. suffixes

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duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
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Results

Affix length

affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
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Are the differences related to ...

the type of affix? ✗

the affix length?

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Manual resegmentation

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Are the differences related to ...

the type of affix? ×

the affix length? ×

the segmentation?

Manual resegmentation

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Are the differences related to ...

the type of affix? ×

the affix length? ×

the segmentation? ×

Type of prosodic integration

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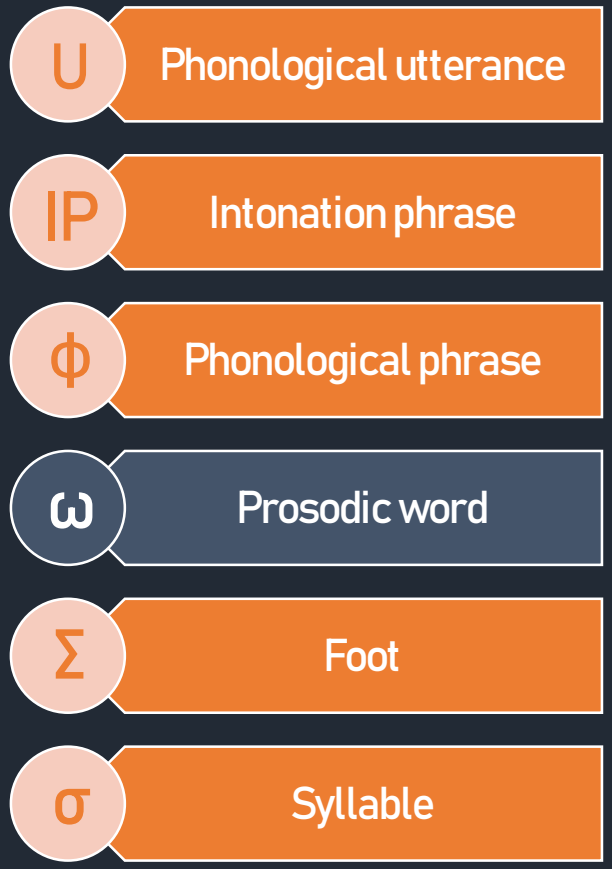
The prosodic hierarchy

- U — Phonological utterance
- IP — Intonation phrase
- ϕ — Phonological phrase
- ω — Prosodic word
- Σ — Foot
- σ — Syllable

Hildebrandt 2015, Raffelsiefen 1999, 2007

Type of prosodic integration

The prosodic hierarchy



Some pword-diagnostics

- onset or coda conditions, LOI-violations
- ambisyllabicity
- stress and relative prominence
- trisyllabic laxing, vowel reduction
- minimal word requirements
- compositionality, type of base

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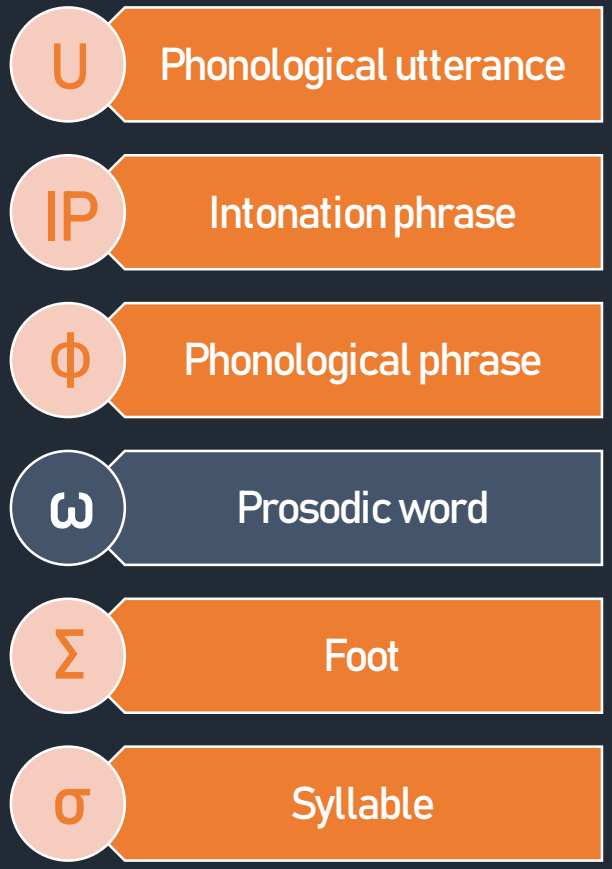

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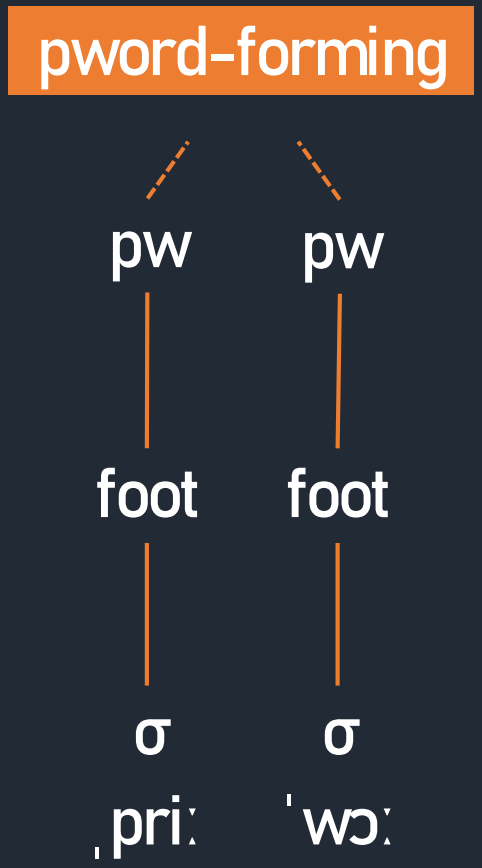
Morpho-prosodic alignment

- A morpheme cannot include multiple pwords, but a pword can include multiple morphemes.

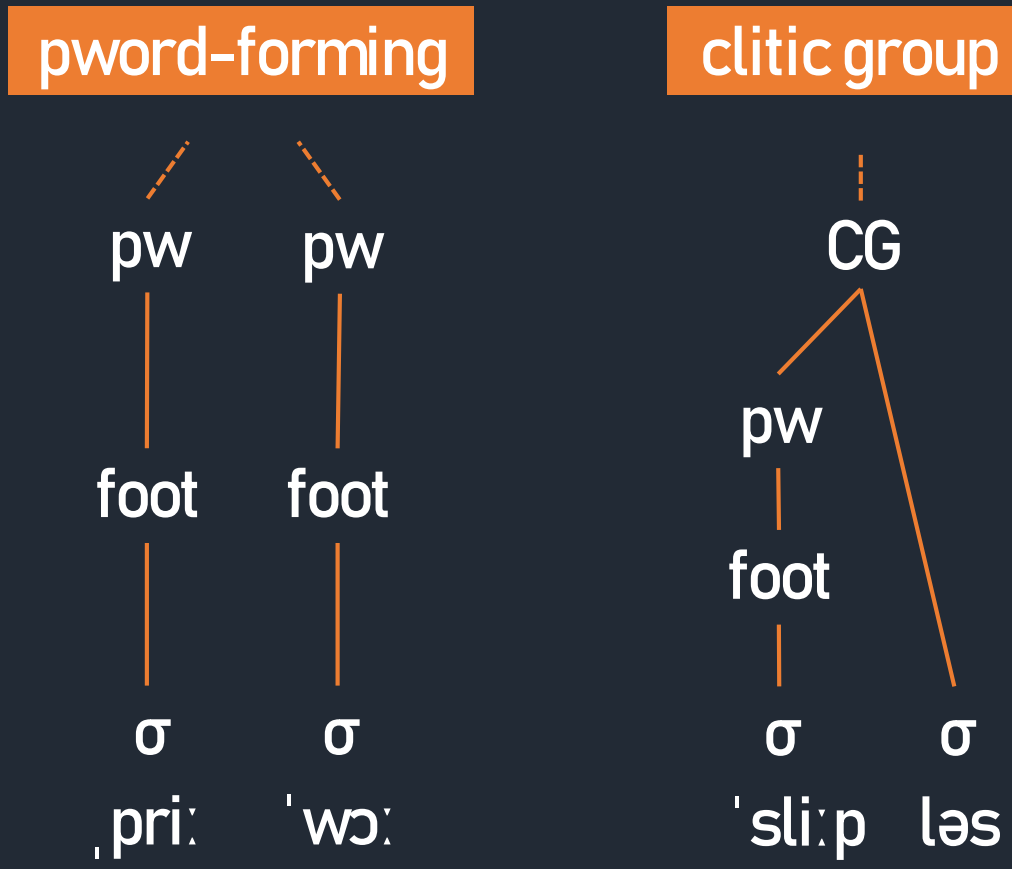
Hildebrandt 2015, Raffelsiefen 1999, 2007

Type of prosodic integration



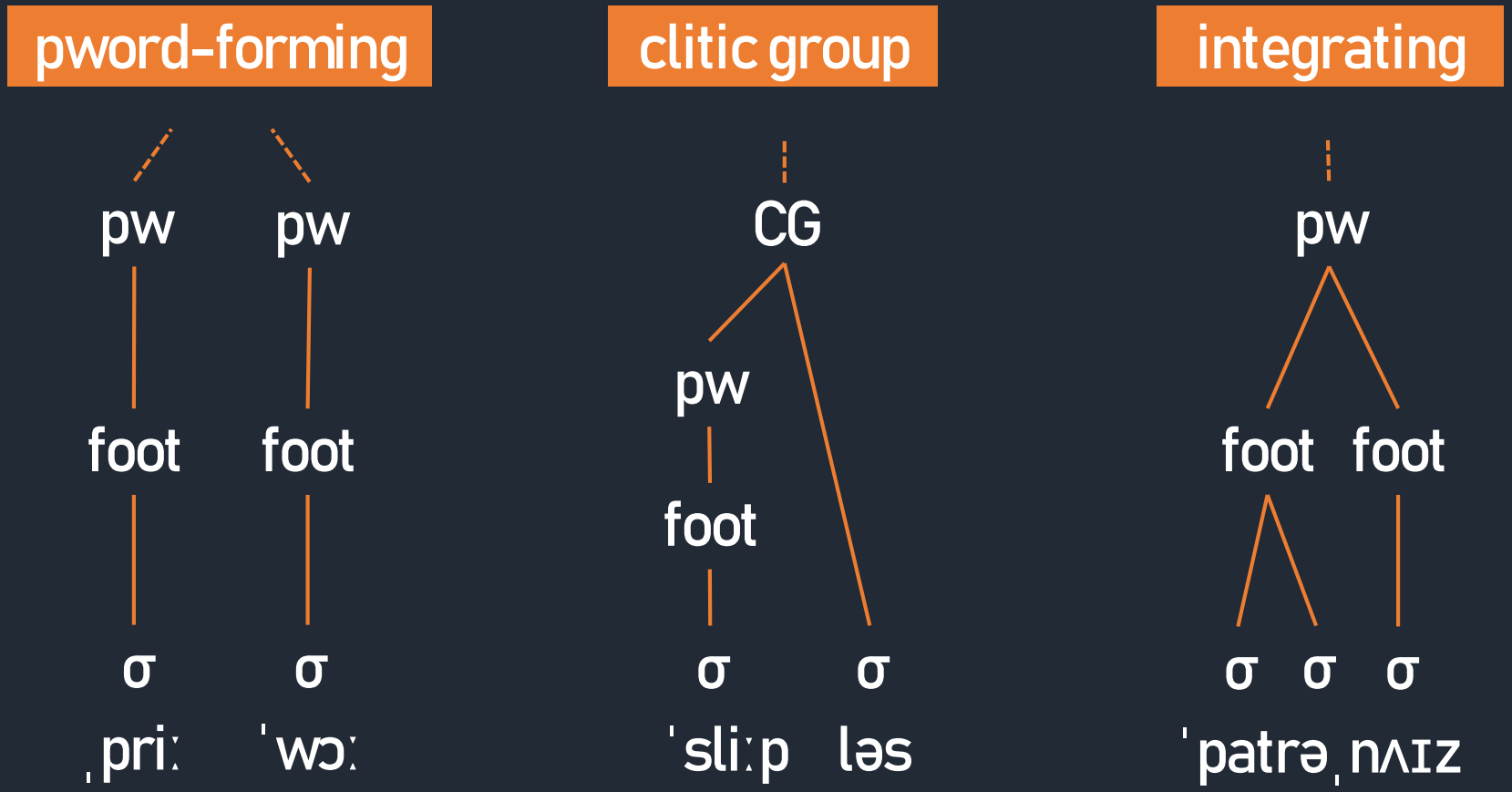
following Raffelsiefen 1999

Type of prosodic integration



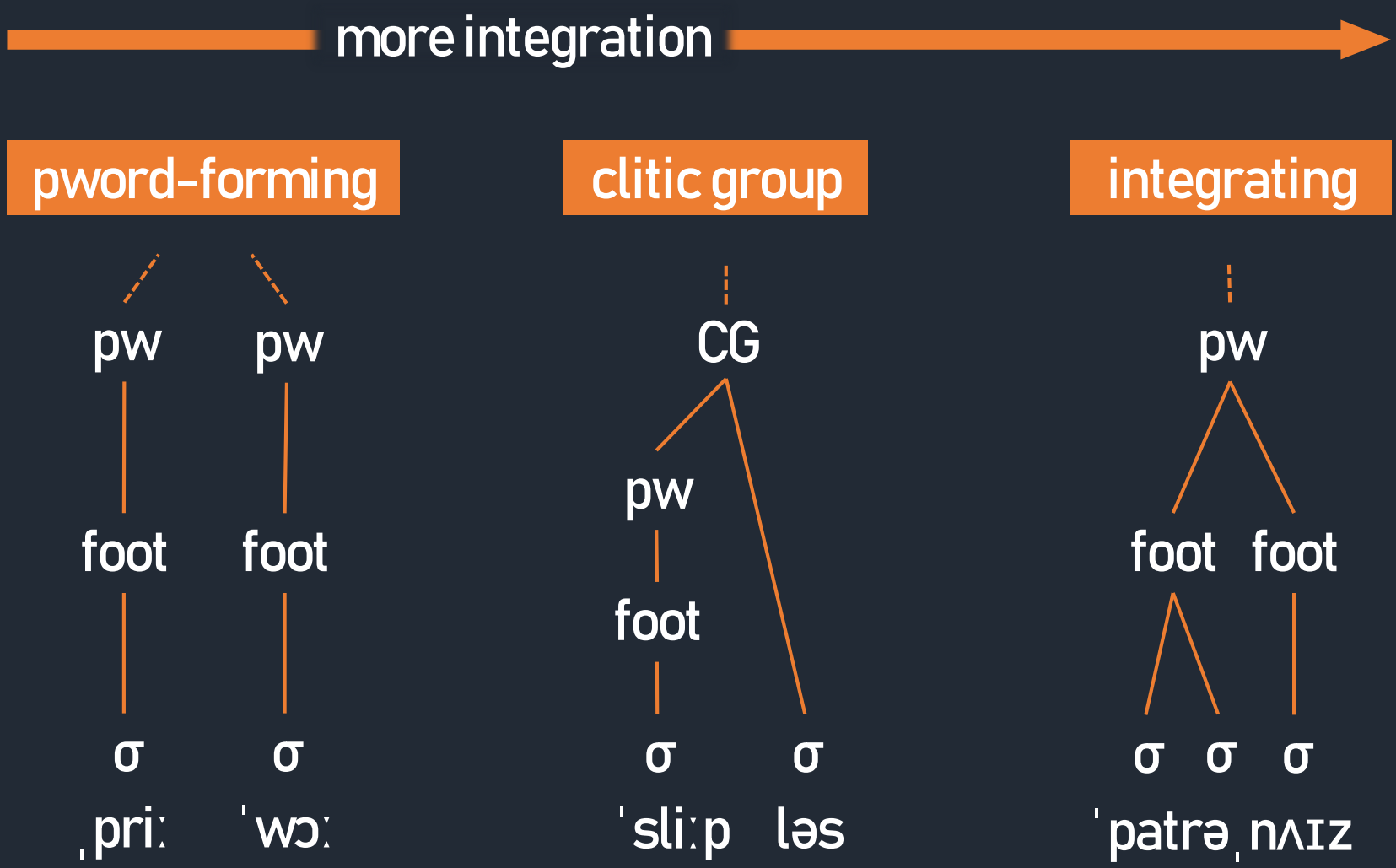
following Raffelsiefen 1999

Type of prosodic integration



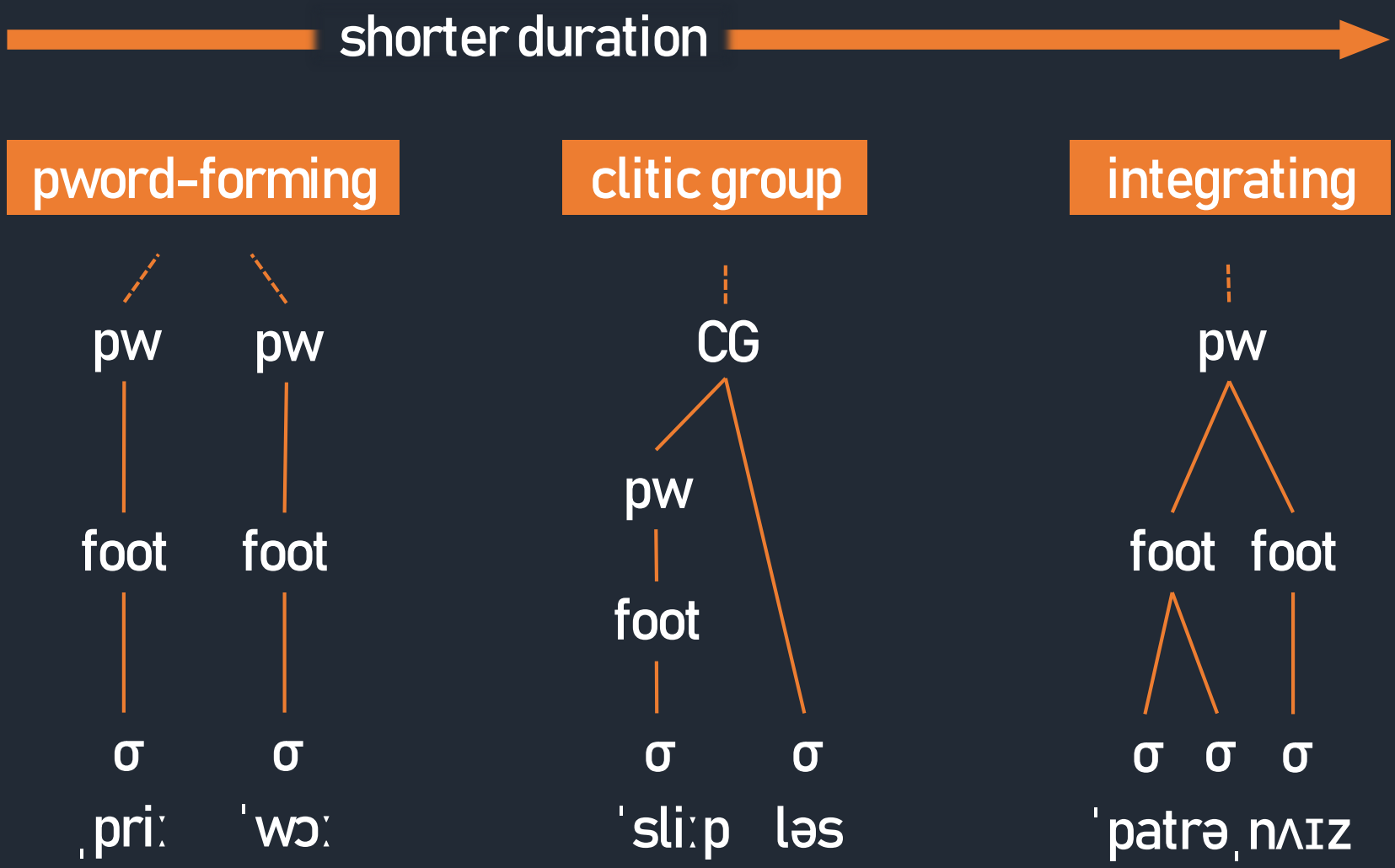
following Raffelsiefen 1999

Type of prosodic integration



following Raffelsiefen 1999

Type of prosodic integration



following Raffelsiefen 1999

Type of prosodic integration

affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

affix	-wise			-less			-ation		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

p < .001 expected direction

p < .001 unexpected direction

Are the differences related to ...

the type of affix? ×

the affix length? ×

the segmentation? ×

prosodic structure?

Type of prosodic integration

category	prosodic word			clitic group			integrates		
affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

affix	-wise			-less			-ation		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

p < .001 expected direction

p < .001 unexpected direction

Are the differences related to ...

the type of affix? ×

the affix length? ×

the segmentation? ×

prosodic structure?

Results

Type of prosodic integration

category	prosodic word			clitic group			integrates		
affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

affix	-wise			-less			-ation		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

p < .001	expected direction	Are the differences related to ...	the type of affix? ✗
p < .001	unexpected direction		the affix length? ✗
			the segmentation? ✗
			prosodic structure?

Results

Type of prosodic integration

category	prosodic word			clitic group			integrates		
affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

affix	-wise			-less			-ation		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

p < .001 expected direction

p < .001 unexpected direction

Are the differences related to ...

the type of affix? ×

the affix length? ×

the segmentation? ×

prosodic structure? ×

Results

Type of prosodic integration

category	prosodic word			clitic group			integrates		
affix	pre-			-ness			-ize		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

affix	-wise			-less			-ation		
duration	word	affix	base	word	affix	base	word	affix	base
word frequency									
base frequency									
relative frequency									

p < .001 expected direction

p < .001 unexpected direction

Are the differences related to ...

- the type of affix? ×
- the affix length? ×
- the segmentation? ×
- prosodic structure? ×

Type of prosodic integration

Meta-model including all affixes

- Additional predictor: type of prosodic integration
- Additional covariate: number of timing slots
- N = 5450

Type of prosodic integration

Meta-model including all affixes

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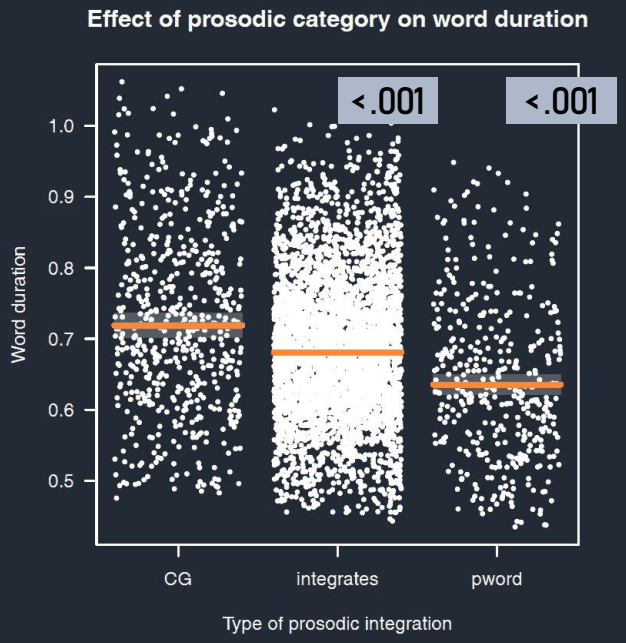

Type of prosodic integration

Meta-model including all affixes

- Additional predictor: type of prosodic integration
- Additional covariate: number of timing slots
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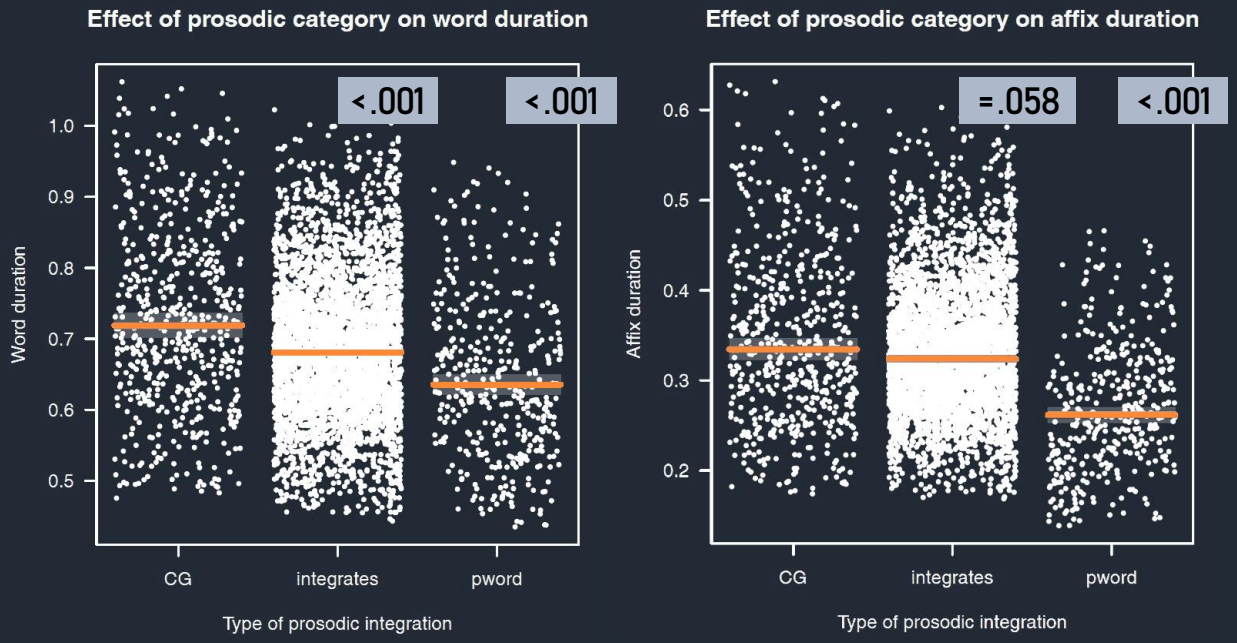

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Meta-model including all affixes

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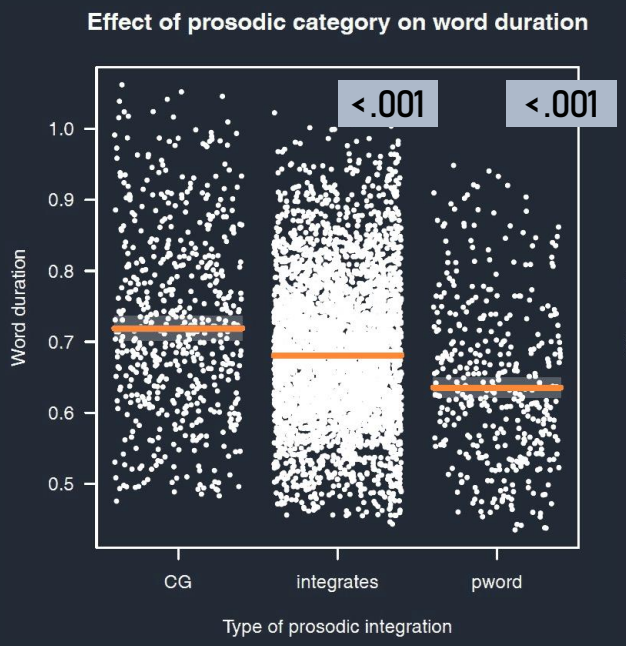
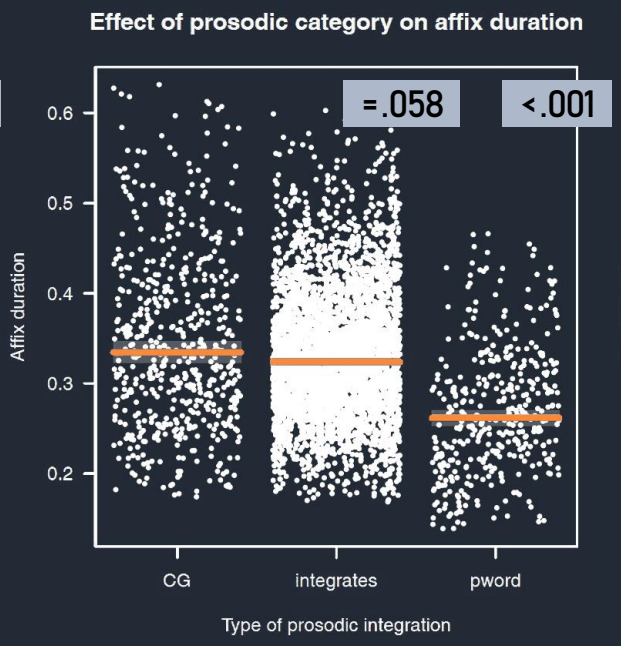
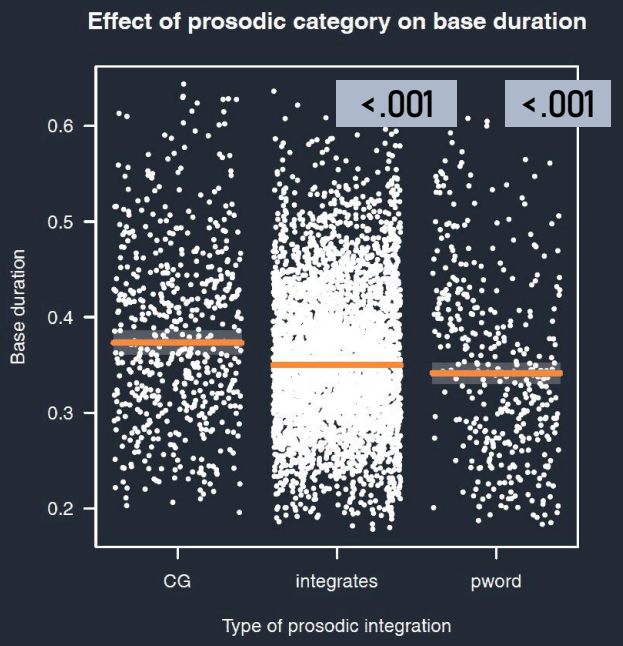




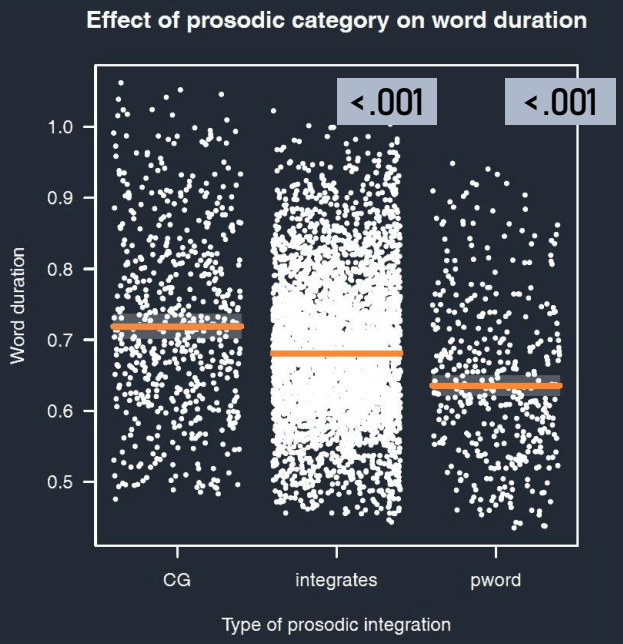


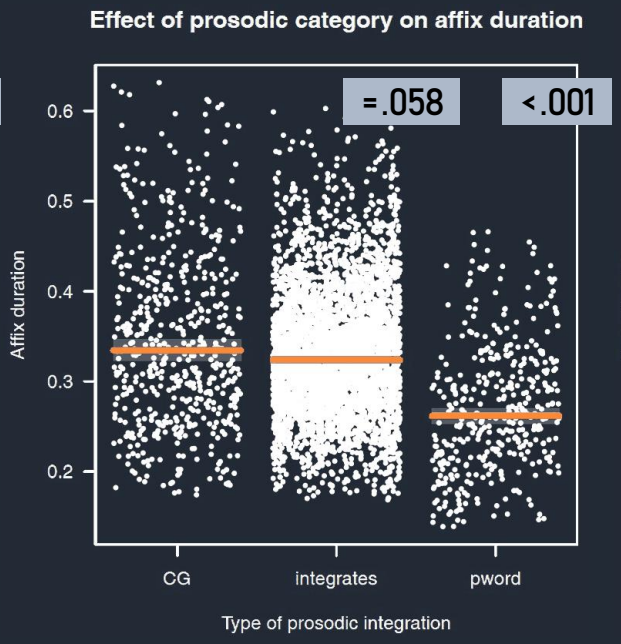
Type of prosodic integration

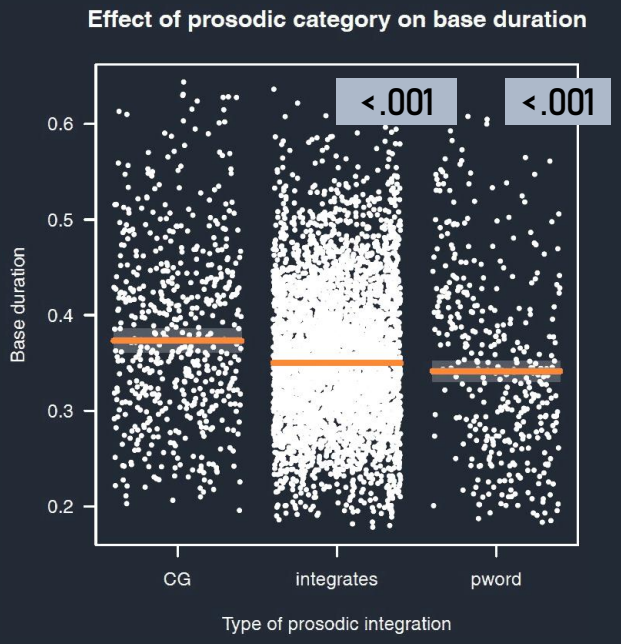
Meta-model including all affixes

- Additional predictor: type of prosodic integration
- Additional covariate: number of timing slots
- N = 5450

- This does not support the predictions of pword integration.







Summary

Summary

In sum, we have a mixed picture.

- Some results are in line with Caselli et al. 2016:
  - All three frequency measures can independently predict duration.
  - This is evidence for both types of storage in the mental lexicon, as well as for segmentability effects.

Summary

In sum, we have a mixed picture.

- Some results are in line with Caselli et al. 2016:
  - All three frequency measures can independently predict duration.
  - This is evidence for both types of storage in the mental lexicon, as well as for segmentability effects.

- However, there are also null effects, which require explanation.
  - So far, we cannot attribute the differences to:
    - the domain of durational measurement (word, affix, base)
    - the type of affix (prefix, suffix)
    - the prosodic category (pword, clitic group, integrating).

Discussion

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Our findings imply that …

› morphological structure can at least partly influence the phonetic output.

Discussion

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- morphological structure can at least partly influence the phonetic output.
- models that prohibit post-lexical access of morphological information (e.g. Kiparsky 1982, Levelt et al. 1999, Bermúdez-Otero 2018) should be revised.

Kiparsky 1982, Levelt et al. 1999, Bermúdez-Otero 2018

Discussion

Our findings imply that …

- morphological structure can at least partly influence the phonetic output.
- models that prohibit post-lexical access of morphological information (e.g. Kiparsky 1982, Levelt et al. 1999, Bermúdez-Otero 2018) should be revised.
- we need to investigate further factors that might cause frequency effects to surface or to not surface.

Kiparsky 1982, Levelt et al. 1999, Bermúdez-Otero 2018

Thank you for listening.

References

Thank you for listening.

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- Raffelsiefen, Renate. 1999. Diagnostics for prosodic words revisited: The case of historically prefixed words in English. In Tracy A. Hall & Ursula Kleinhenz (eds.), *Studies of the phonological word*. 133–201. Amsterdam, Philadelphia: Benjamins.
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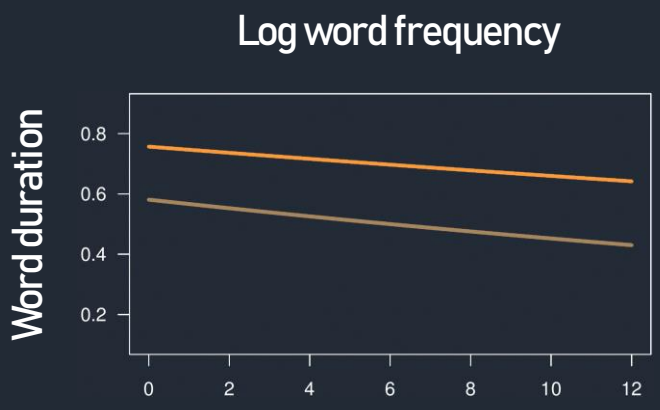
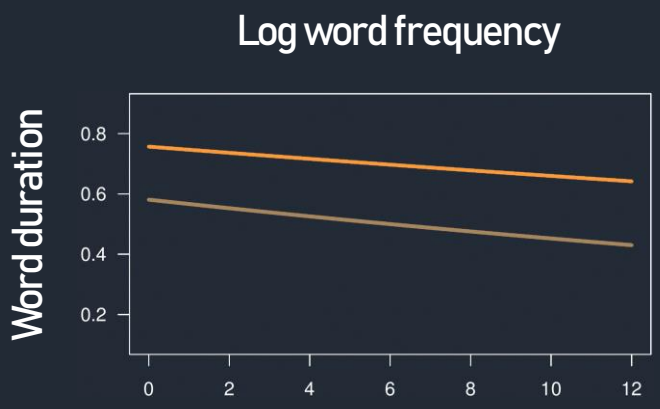
References

Thank you for listening.

› Vitevitch, Michael S., & Luce, Paul A. 2004. A web-based interface to calculate phonotactic probability for words and nonwords in English. *Behavior Research Methods, Instruments, and Computers* 36.3: 481–487.

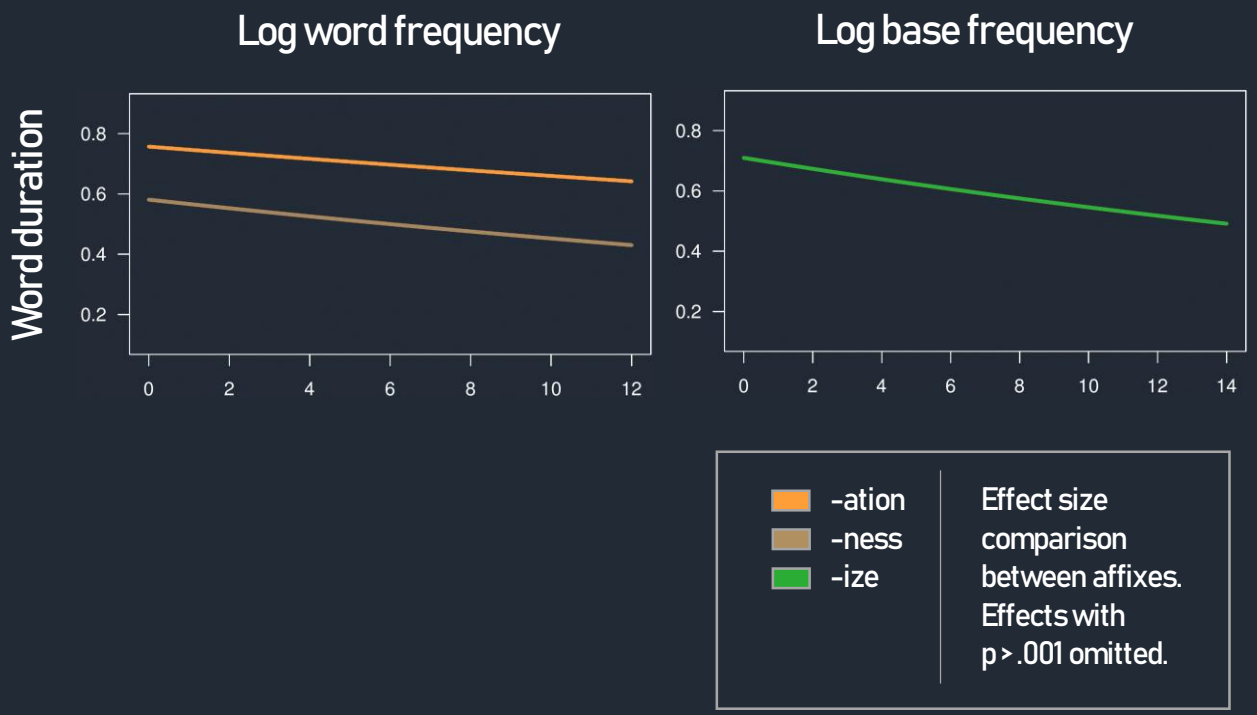
Appendix

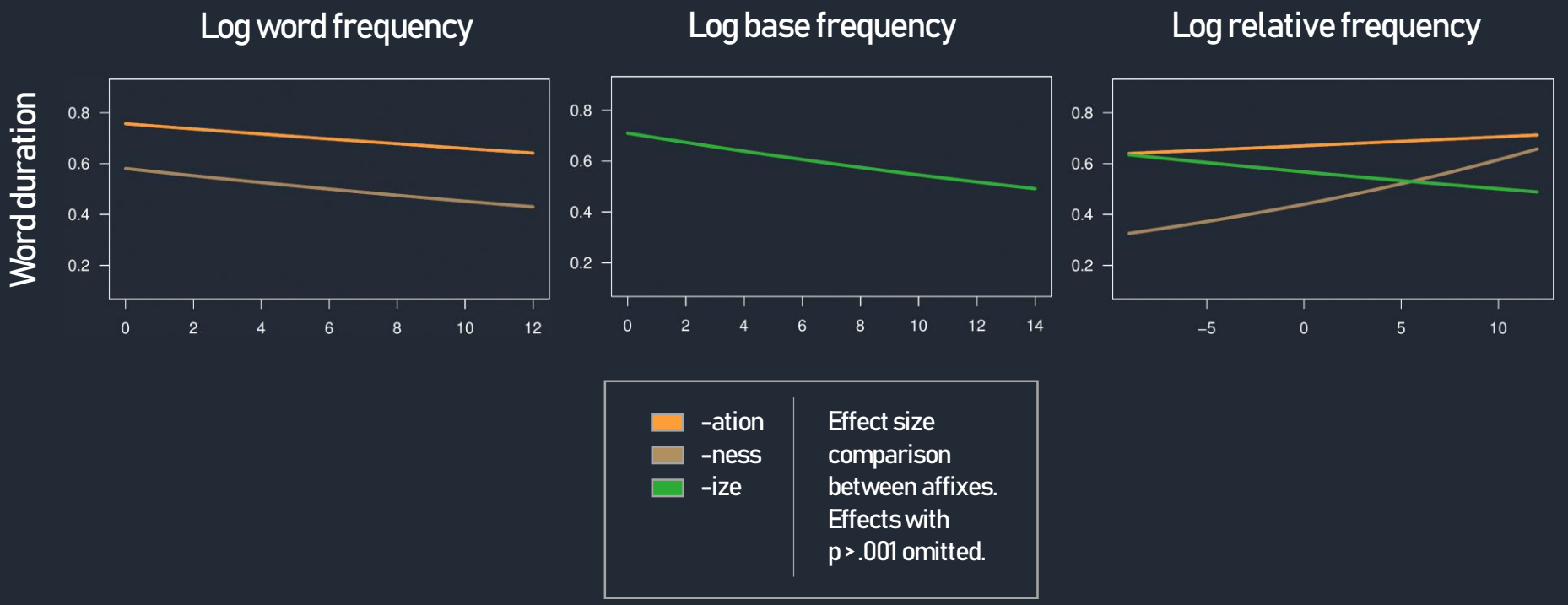

Log word frequency
Word duration
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12



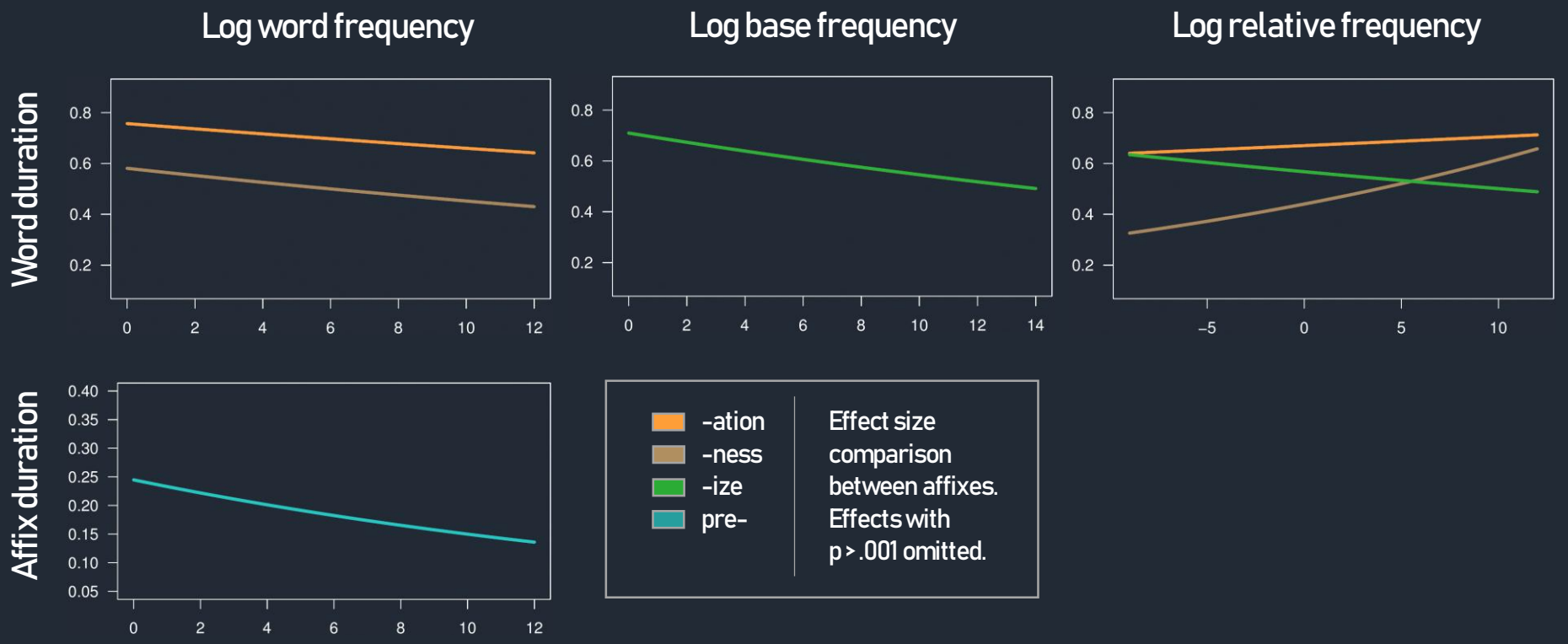
-ation
-ness

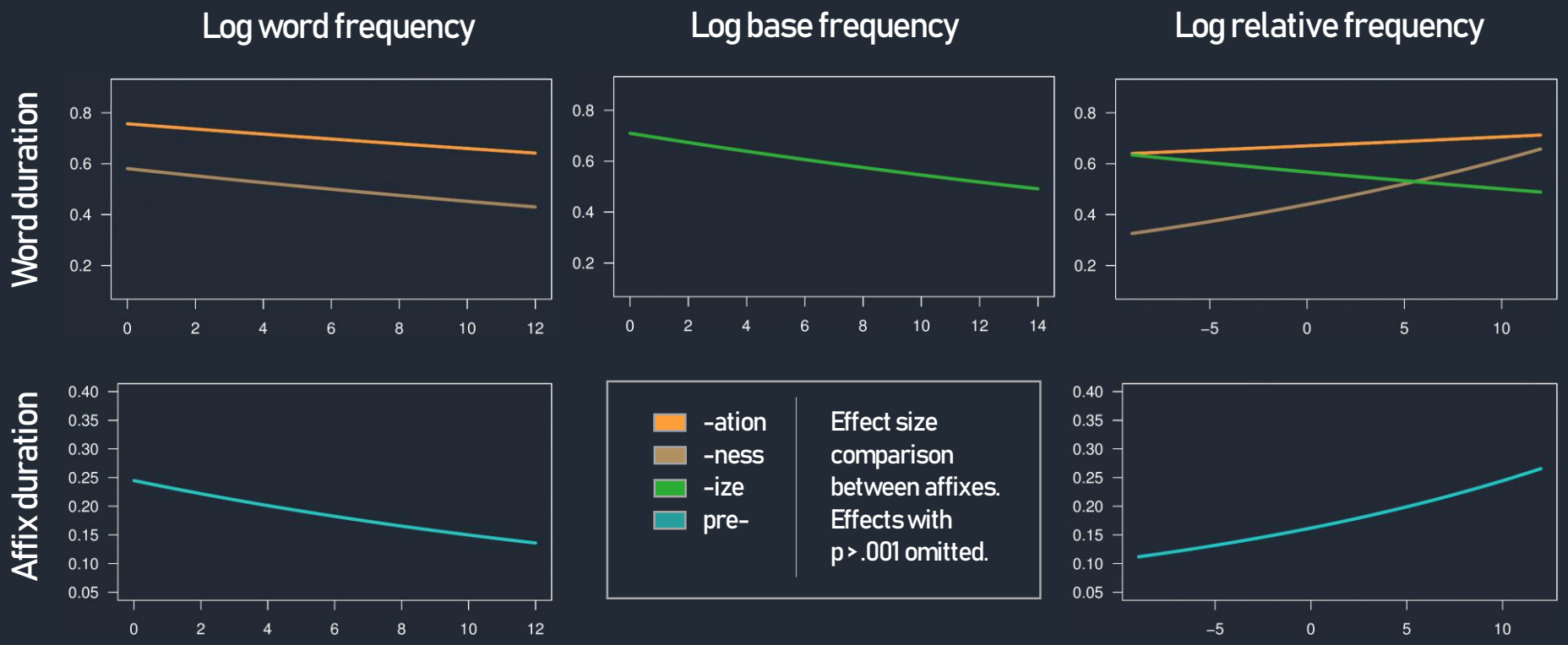
Effect size comparison between affixes. Effects with $p > .001$ omitted.

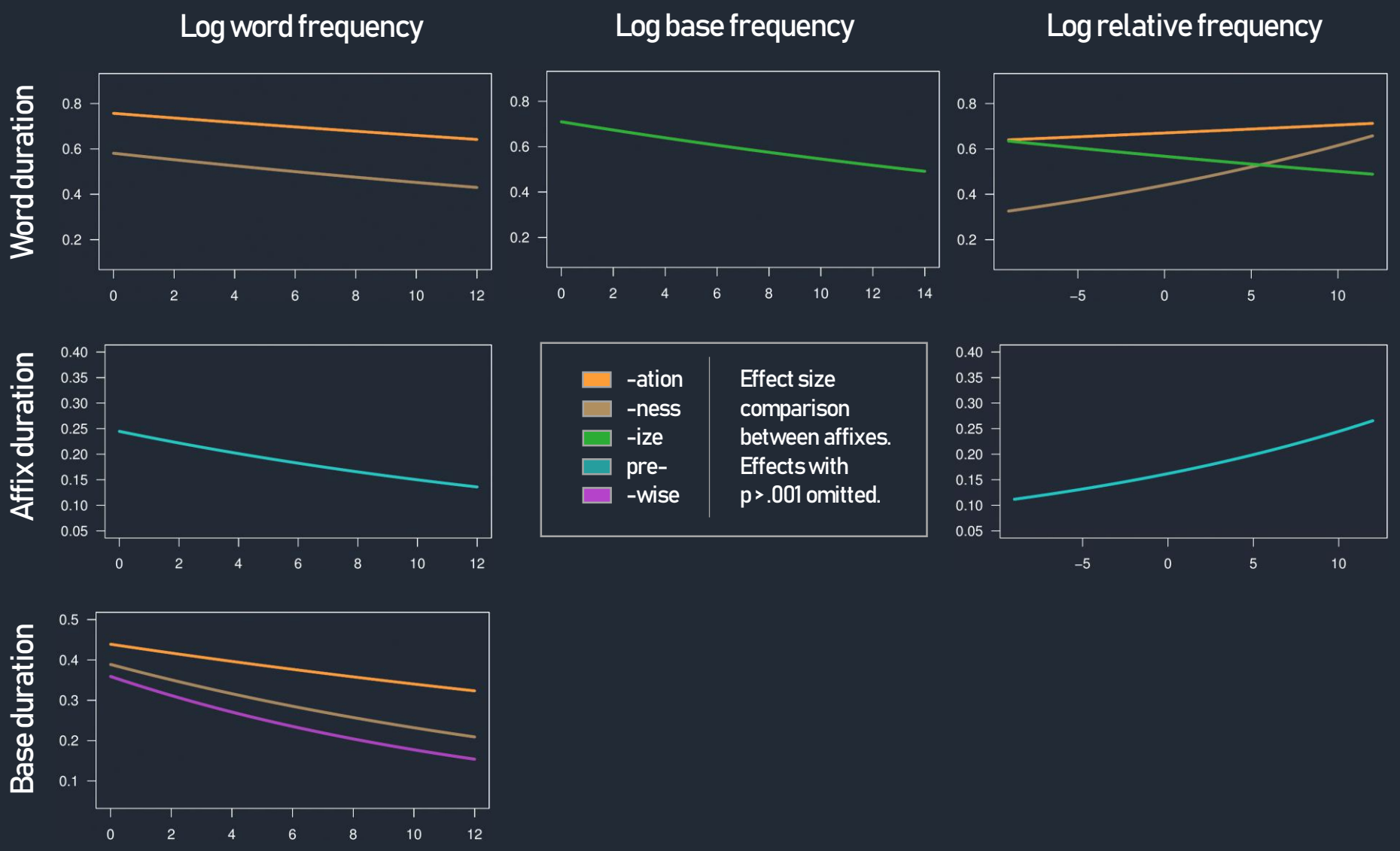

Log word frequency
Log base frequency
Word duration
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
-ation
-ness
-ize
Effect size comparison between affixes. Effects with p > .001 omitted.

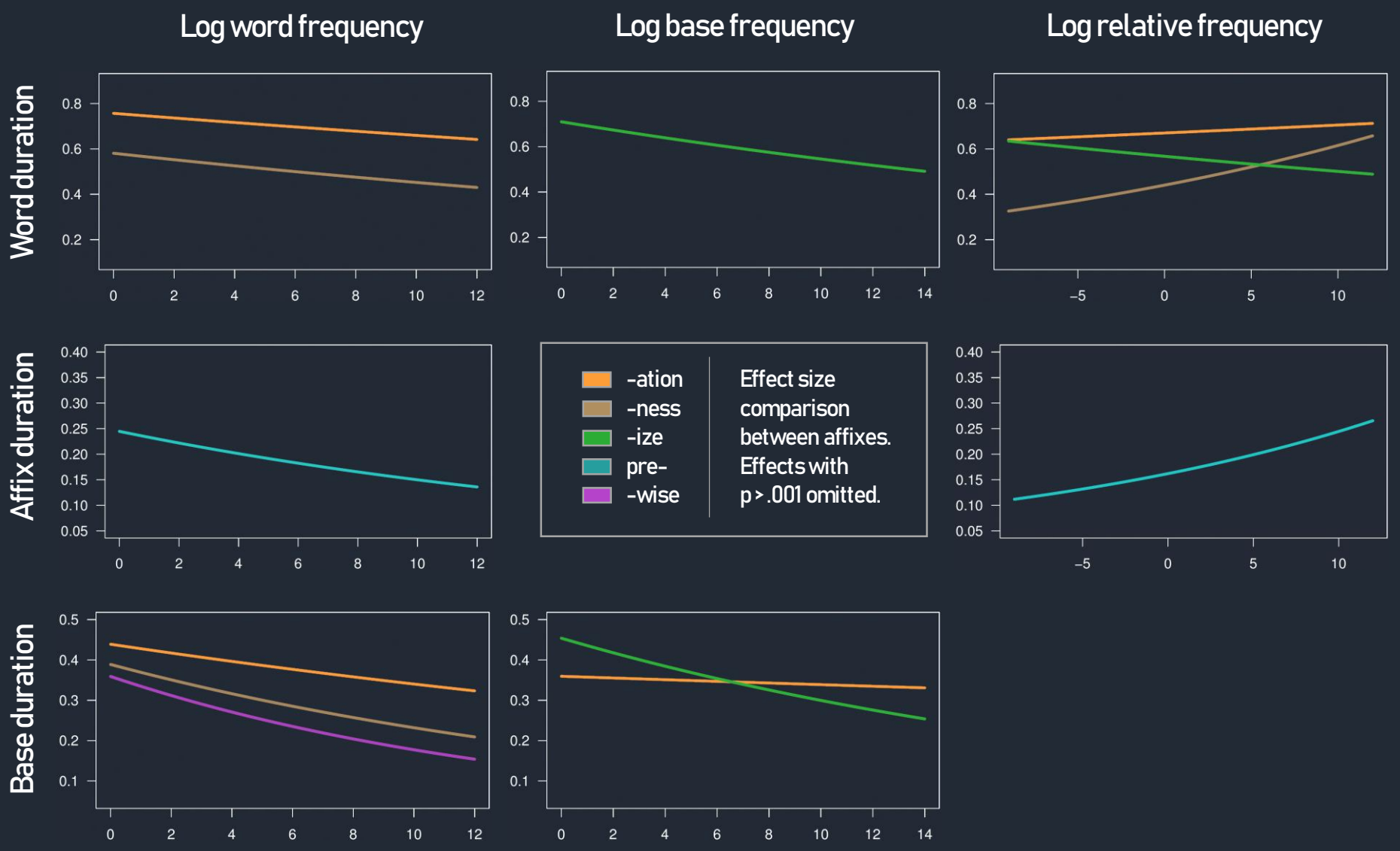

Log word frequency
Log base frequency
Log relative frequency
Word duration
0.8
0.6
0.4
0.2
0
2
4
6
8
10
12
14
−5
5
-ation
-ness
-ize
Effect size comparison between affixes. Effects with p > .001 omitted.

Appendix


Log word frequency
Log base frequency
Log relative frequency
Word duration
Affix duration
0.8
0.6
0.4
0.2
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0 2 4 6 8 10 12
0 2 4 6 8 10 12 14
−5 0 5 10
-ation
-ness
-ize
pre-
Effect size comparison between affixes. Effects with p > .001 omitted.


Log word frequency
Log base frequency
Log relative frequency
Word duration
Affix duration
-ation
-ness
-ize
pre-
Effect size comparison between affixes. Effects with p > .001 omitted.


Log word frequency
Log base frequency
Log relative frequency
Word duration
Affix duration
Base duration
-ation
-ness
-ize
pre-
-wise
Effect size comparison between affixes. Effects with p > .001 omitted.


Log word frequency
Log base frequency
Log relative frequency
Word duration
Affix duration
Base duration
-ation
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-ize
pre-
-wise
Effect size comparison between affixes. Effects with p > .001 omitted.

Log word frequency
Log base frequency
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Word duration
Affix duration
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pre-
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Effect size comparison between affixes. Effects with p > .001 omitted.