Is duration a causal factor of lenition?
Evidence from Spanish

Karolina Broś

University of Warsaw

What is lenition?

- ❏ sonority, vowel-likeness (Lavoie 2001, Szigetvari 2008)

- ❏ effort reduction (Kirchner 1998)

- ❏ articulatory undershoot (Bauer 2008)

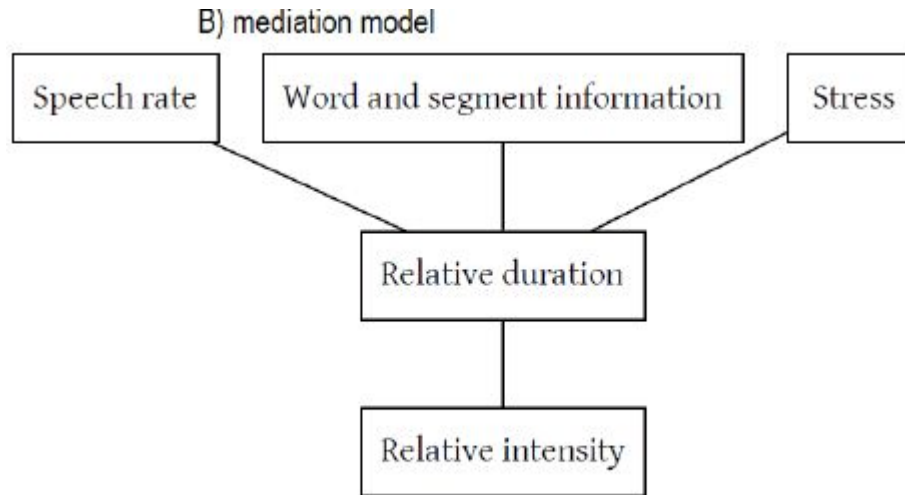- ❏ "continuity lenition" (Kingston 2008, Katz 2016)

Markers of lenition

- ❏ reduced duration
- ❏ increased intensity
- ❏ speech rate
- ❏ stress
- ❏ content/informativity
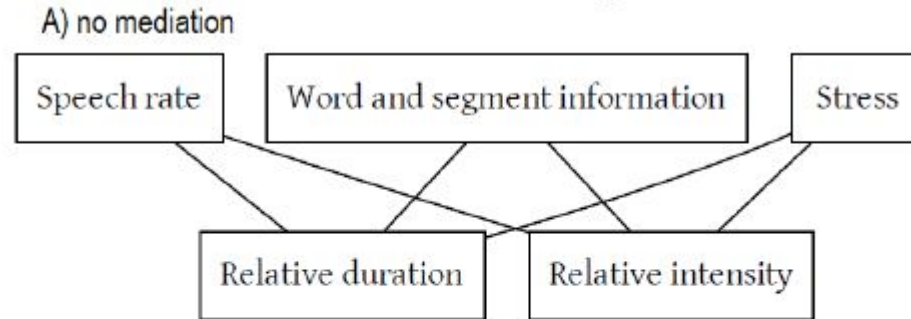- ❏ frequency

Cohen & Gleason's (2020) proposal

duration:

➔ is **primary** to intensity changes

➔ acts as a **mediator** between extrinsic factors and intensity changes

➔ once we control it, the influence of other factors **on intensity** disappears

➔ **but not the other way around!**

➔ **indirect influence** of stress, informativity and speech rate **on intensity**

➔ **direct influence** of stress, informativity and speech rate **on duration**

Cohen & Gleason's model – hypothesis 1

B) mediation model

| Speech rate | Word and segment information | Stress |

Relative duration

Relative intensity

Cohen & Gleason's model – hypothesis 2

A) no mediation

| Speech rate | Word and segment information | Stress |

| Relative duration | Relative intensity |

Corpora – comparison

Cohen & Gleason (2020)

Buckeye corpus of Conversational English (Pitt et al. 2007)

40 speakers

free conversations with interviewers

~12,600 tokens of intervocalic obstruents

~620 word types

Broś et al. (2021)

Corpus of dialectal Spanish

44 speakers from Gran Canaria

semi-structured interviews

13,688 underlying postvocalic /p t k b d g/

annotated in Praat as surface [p t k], [b d g] or [β ð ɣ]

total corpus size: 4,481 utterances, 111,317 sounds, 2771 unique words

Why is it a good sample?

UR		voiceless stop	voiced stop	approximant	Ø
/p/	*guapo* 'pretty'	['gwa.po]	['gwa.bo]	['gwa.β̞o]	['gwa.o]
	se parece 'is similar'	[se.pa.'ɾe.se]	[se.ba.'ɾe.se]	[se.β̞a.'ɾe.se]	[se.a.'ɾe.se]
	después 'afterwards'	[de.'pwe]	[de.'bwe]	[de.'β̞we]	
/b/	*cabeza* 'head'			[ka.'β̞e.sa]	[ka.'e.sa]
	la vela 'the candle'		[la.'be.la]	[la.'β̞e.la]	[la.'e.la]
	las velas 'the candles'	[la.'pe.la]	[la.'be.la]	[la.'β̞e.la]	

Possible problems

Duration - hard to delimit approximants

Voicing - what is voiced vs. what is voiceless?
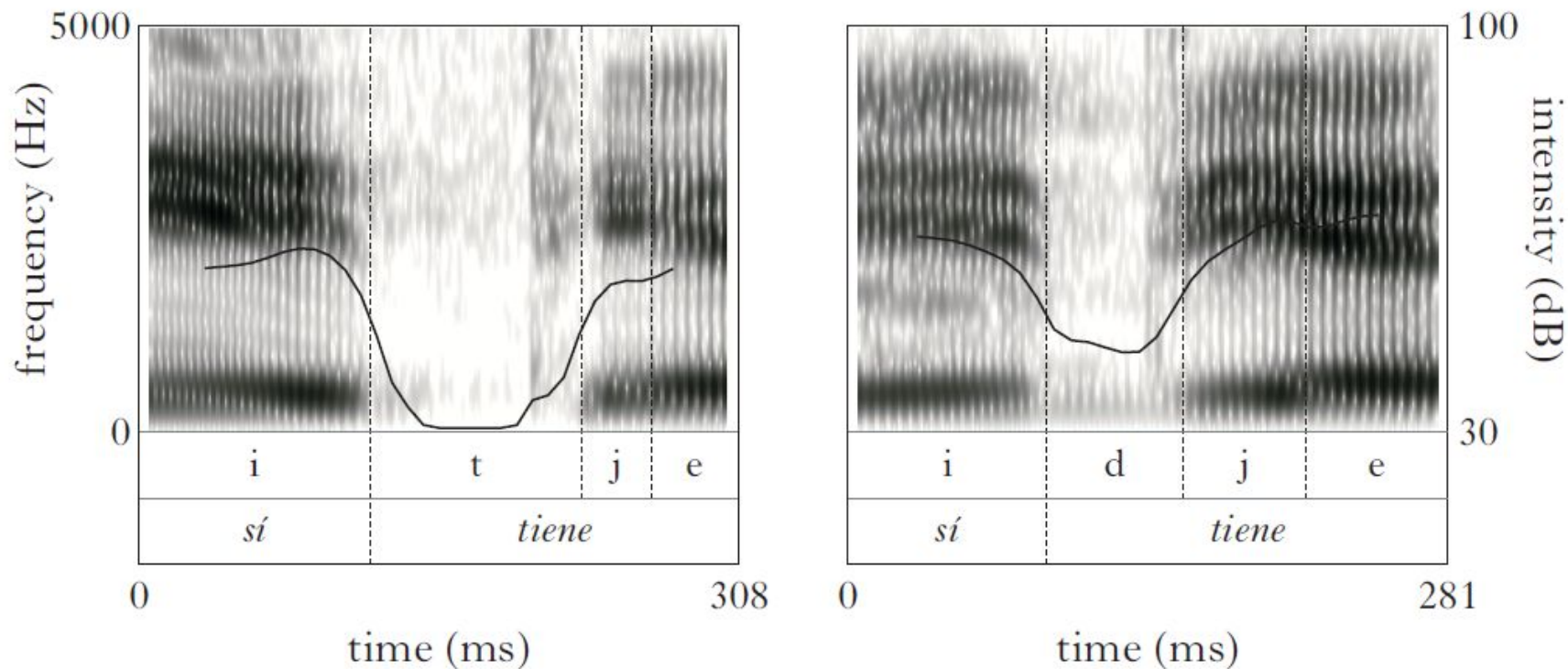
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Figure 1

Two instances of an underlying /t/ in the phrase *sí tiene* 'yes, he/it has', pronounced as [t] (left) and [d] (right) by the same speaker.
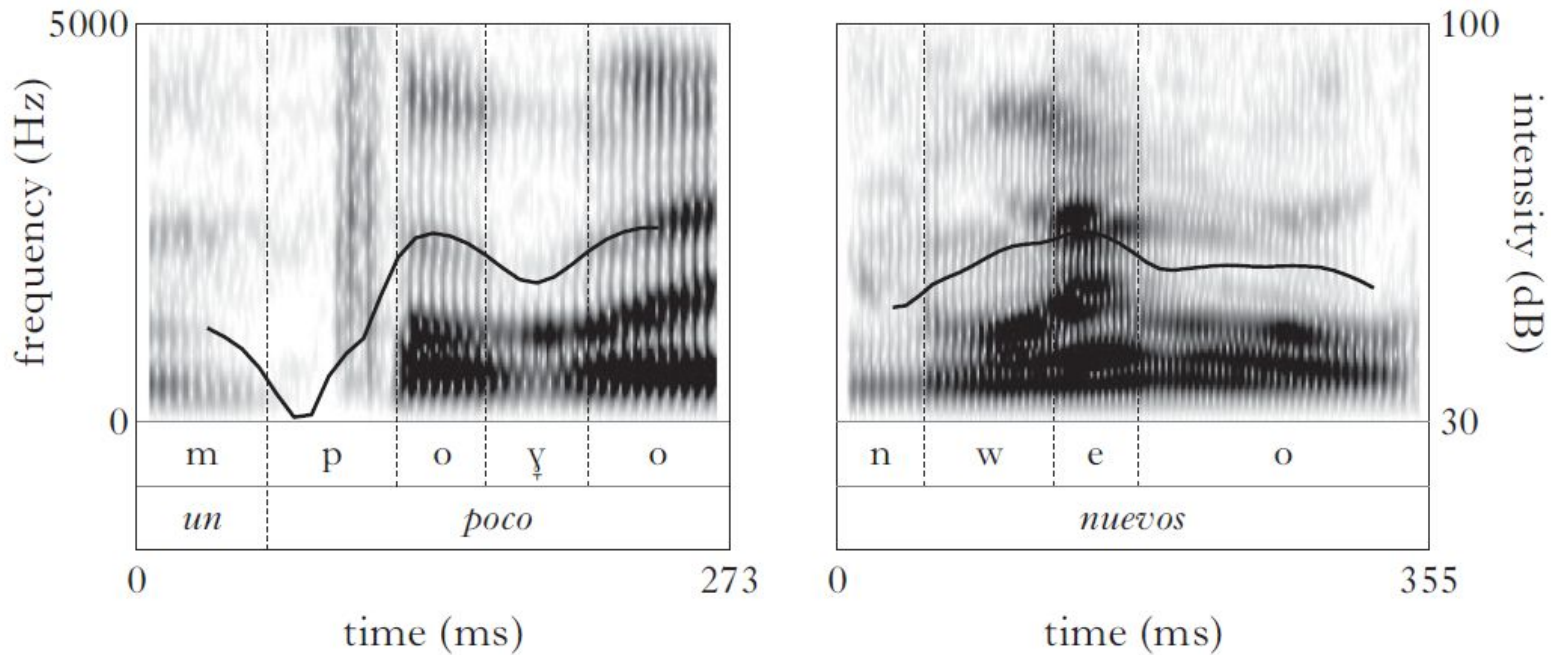
Figure 2

/k/ approximantised to [ɣ] in the sequence *un poco* /un poko/ [m.po.ɣo]
'a bit' (left), and deleted underlying /b/ between [we] and [o] in the
word *nuevos* /nwebos/ [nwe.o] 'new (PL.MASC)', where it was impossible
to discern the approximant in the signal, although a slight dip in intensity
might at first sight indicate the presence of the consonant (right).

Variables

relative duration

– sound / total VC duration

intensity difference

– V max -C min intensity

speechrate

– number of phones / s per file

word status

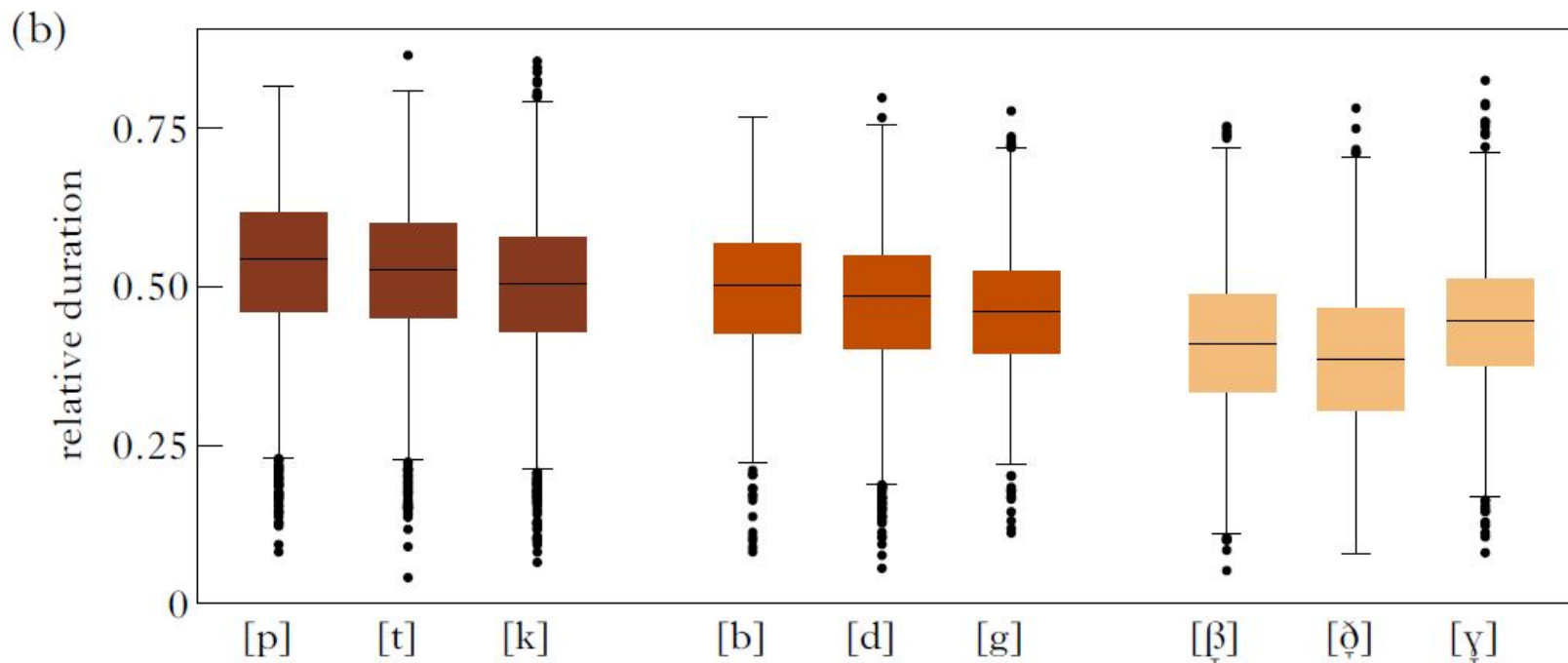– content or a function word

position

– word-initial or word-medial

stress

– primary stress on the following vowel

———

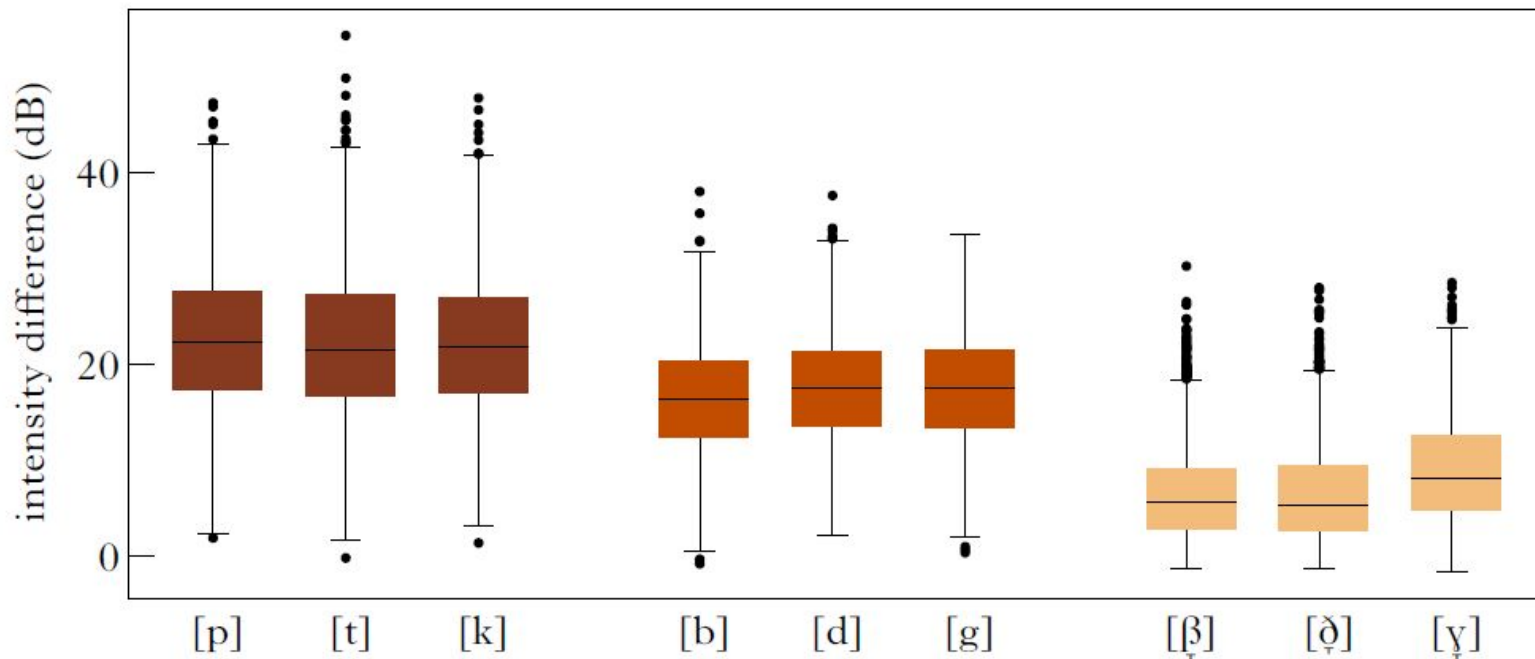# General results (as per Broś et al. 2021)

weakening involves both intensity and duration changes in the expected direction
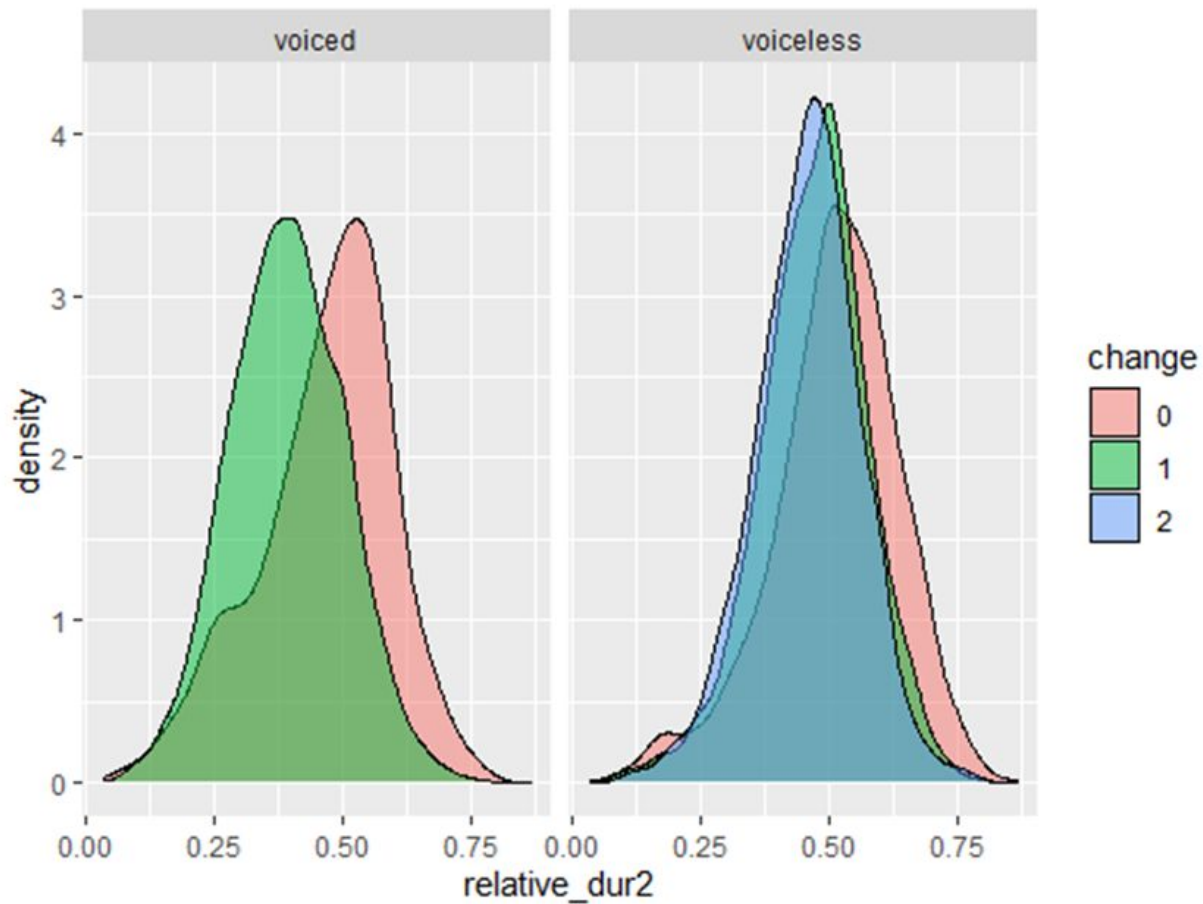
General results (as per Broś et al. 2021)

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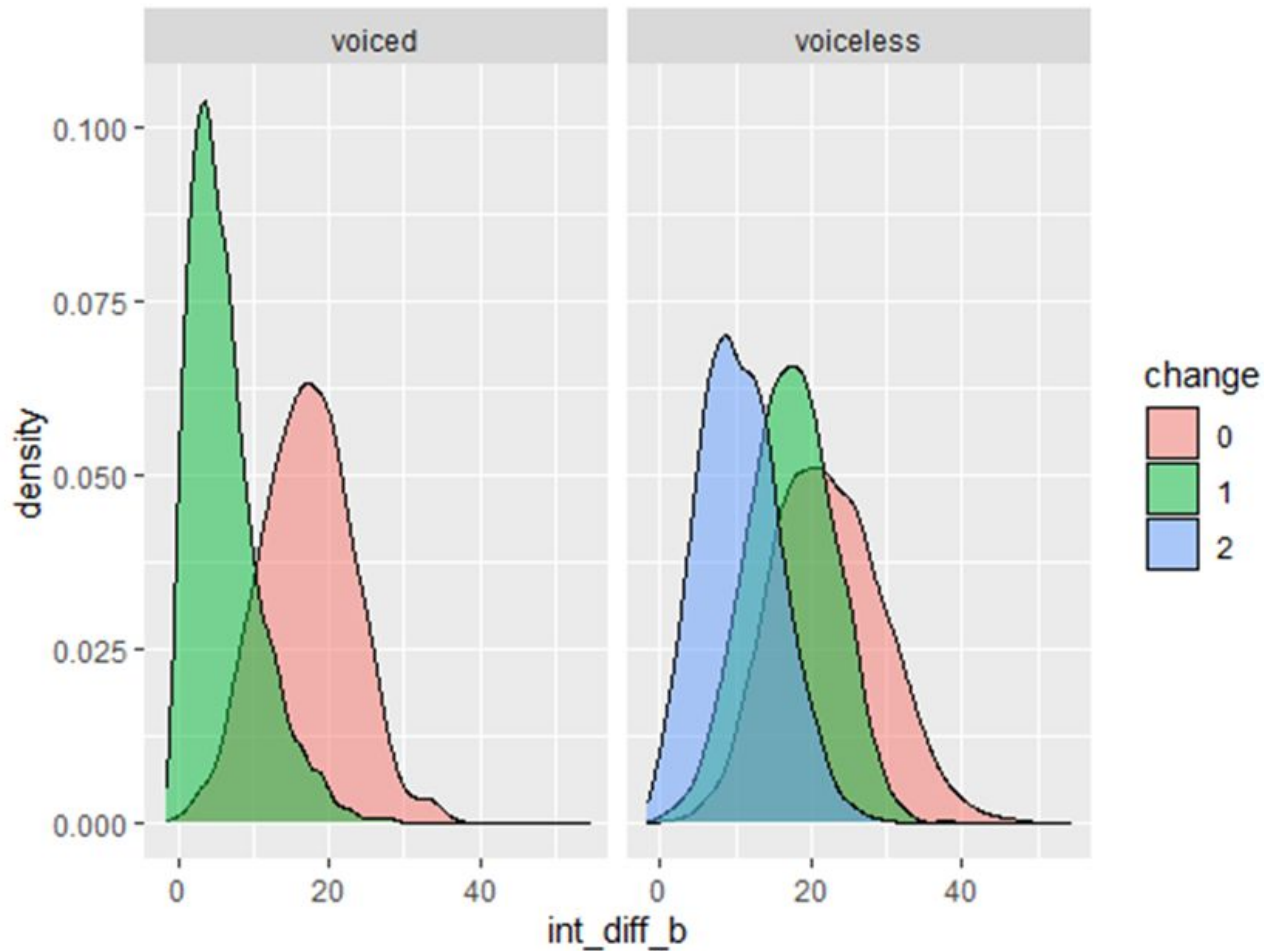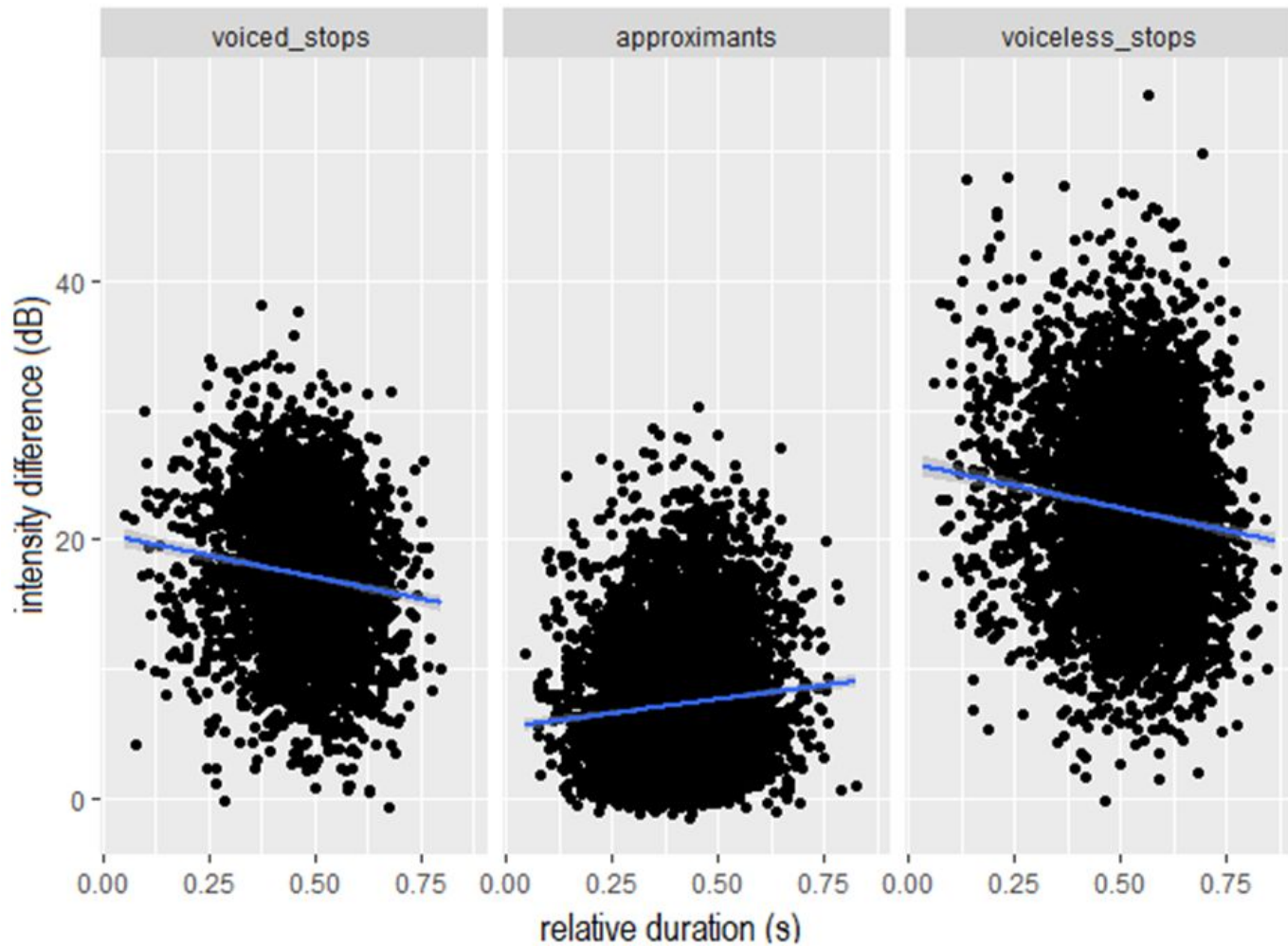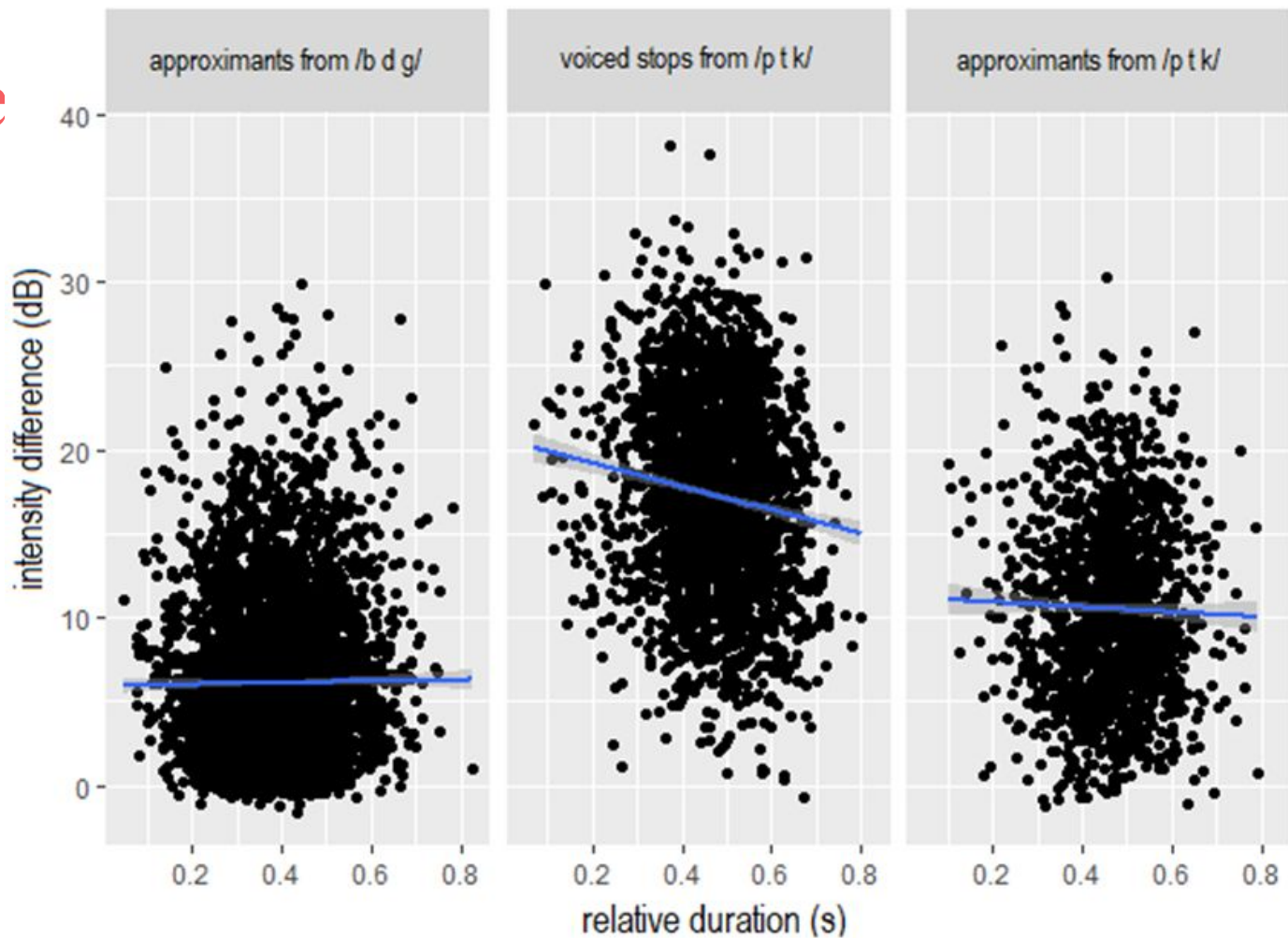
Descriptive results

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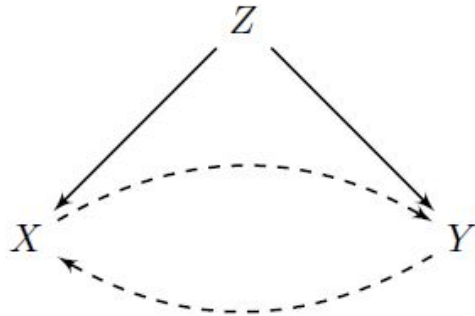**Descriptive results**

Replication of

Cohen &
Gleason's study

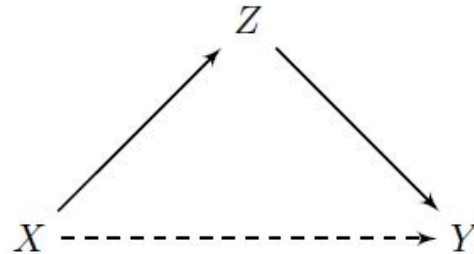# Mediation analysis

conditional independence:

X and Y can be conditionally independent when Z is held constant (Z is a mediator, the causal relation is indirect)

adding a factor to a model serves as a proxy of holding it constant

(a)

(b)

(c)
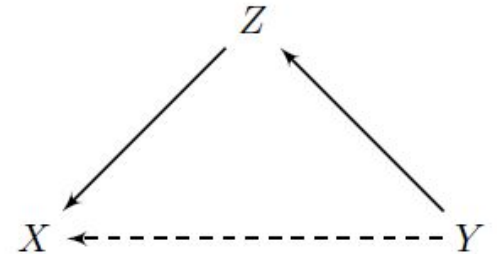
Preliminary analysis

Intensity models	Model without duration			Model with duration		
	estimate	*t value*	*p value*	*estimate*	*t value*	*p value*
speechrate	-0.04	-0.460	0.645	-0.033	-0.378	0.705
word_status:function_word	0.09	0.480	0.631	0.089	0.472	0.637
position:medial	-0.718	-5.986	<0.001	-0.691	-5.747	<0.001
stress:stressed	-0.431	-3.782	<0.001	-0.394	-3.457	<0.001
relative_duration				-2.344	-5.836	<0.001
Duration models	**Model without intensity**			**Model with intensity**		
	estimate	*t value*	*p value*	*estimate*	*t value*	*p value*
speechrate	0.003	2.142	0.0326	0.003	2.047	0.041
word_status:function_word	0.0005	0.149	0.8818	0.001	0.209	0.835
position:medial	0.012	4.749	<0.001	0.011	4.463	<0.001
stress:stressed	0.015	6.368	<0.001	0.015	6.179	<0.001
intensity difference				-0.001	-5.645	<0.001

Mediation analysis results

the relationship between intensity and duration does not seem to be causal

- ❏ in a model predicting intensity, controlling for the effect of duration does not cancel out the effects of stress or position in a word

- ❏ in a model predicting duration, the same happens

- ❏ speech rate was only significant in models with duration while word status did not reach significance in any model

Cohen & Gleason's model – hypothesis 2

A) no mediation

| Speech rate | Word and segment information | Stress |

| Relative duration | Relative intensity |
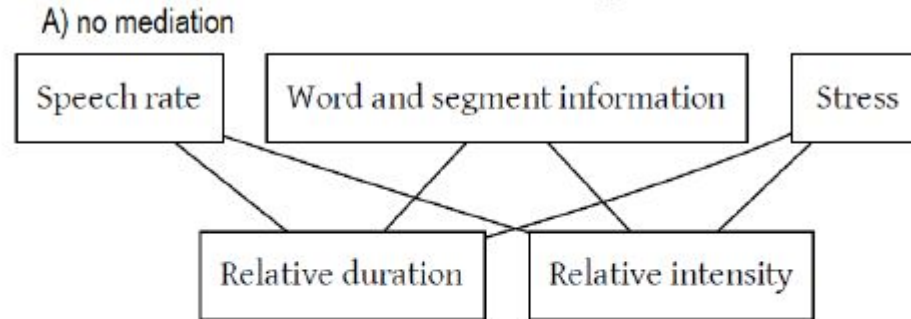
Modifications

following Cohen (2017) and
Cohen & Gleason (2020)

pointwise speech rate – ratio between a given word's duration and the mean duration of all instances of that word in the corpus, log-transformed

log word frequency – the number of times each word was observed in the corpus, log-transformed

different measurement of **intensity** and

relative duration

Intensity – basic model

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	1.311e+01	2.869e+00	5.359e+00	4.567	0.005071 **
pwise speechrate	2.646e+00	1.404e-01	1.134e+04	18.847	**< 2e-16 *****
log_wd_freq	-1.924e-01	9.414e-02	6.209e+02	-2.044	**0.041416 ***
word status	6.371e-01	2.752e-01	9.231e+02	2.315	**0.020832 ***
position	-5.893e-01	1.610e-01	5.114e+03	-3.661	**0.000254 *****
stress	1.103e-01	1.499e-01	7.783e+03	0.736	0.461761

Intensity – mediation model

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	1.266e+01	2.852e+00	5.445e+00	4.437	0.005539 **
pwise speechrate	2.655e+00	1.405e-01	1.134e+04	18.898	**< 2e-16 *****
log_wd_frequency	-1.884e-01	9.384e-02	6.155e+02	-2.008	**0.045070 ***
word status	6.333e-01	2.745e-01	9.129e+02	2.308	**0.021241 ***
position	-6.045e-01	1.609e-01	5.059e+03	-3.756	**0.000175 *****
stress	9.311e-02	1.501e-01	7.780e+03	0.620	0.534971
relative duration	1.019e+00	5.080e-01	1.238e+04	2.005	**0.044969 ***

Duration – basic model

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	4.415e-01	2.397e-02	5.589e+00	18.415	**3.23e-06** ***
pwise speechrate	-8.774e-03	2.497e-03	1.151e+04	-3.514	**0.000442** ***
word status	5.822e-03	4.407e-03	7.135e+02	1.321	0.186861
position	1.311e-02	2.747e-03	3.975e+03	4.771	**1.90e-06** ***
stress	1.780e-02	2.588e-03	6.233e+03	6.879	**6.63e-12** ***
log_wd_frequency	-3.987e-03	1.476e-03	5.016e+02	-2.702	**0.007134** **

Duration – mediation model

	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	4.365e-01	2.306e-02	5.712e+00	18.925	2.26e-06 ***
pwise speechrate	-9.789e-03	2.532e-03	1.158e+04	-3.867	**0.000111 *****
word_status	5.477e-03	4.387e-03	7.018e+02	1.248	0.212330
position	1.331e-02	2.743e-03	3.918e+03	4.851	**1.28e-06 *****
stress	1.777e-02	2.584e-03	6.137e+03	6.877	**6.70e-12 *****
log_wd_frequency	-3.905e-03	1.468e-03	4.927e+02	-2.661	**0.008048 ****
intensity difference	3.811e-04	1.573e-04	1.200e+04	2.422	**0.015431 ***

Changing intensity and duration calculations

Segment mean minimum intensity - mean minimum intensity of all surface tokens associated with the same intervocalic underlying segment produced by the same speaker, excluding the token segment itself

Segment relative minimum intensity - difference between the segment's minimum intensity and its mean minimum intensity.

Segment relative duration - log ratio between the segment's actual duration and mean duration of segments with the same underlying form.

Intensity – final model (work in progress)

	Estimate	t value	Pr(>|t|)	Estimate	t value	Pr(>|t|)
(Intercept)	2.1051	1.202	0.23547	1.347e+00	0.783	0.4375
pwise speechrate	**-2.0747**	**-14.254**	**< 2e-16 *****	**7.320e-01**	**5.304**	**1.15e-07 *****
log_wd_freq	0.1307	1.230	0.21918	8.810e-02	1.052	0.2934
word status	**-0.8008**	**-2.620**	**0.00893 ****	**-4.761e-01**	**-1.932**	**0.0537 .**
position	0.2206	1.292	0.19645	1.569e-01	1.074	0.2830
stress	**-0.6369**	**-4.023**	**5.78e-05 *****	**-1.815e-01**	**-1.321**	**0.1864**
sound_dur_ratio				**-1.081e+01**	**-59.281**	**< 2e-16 *****

Duration – final models (work in progress)

	Estimate	t value	Pr(>|t|)	Estimate	t value	Pr(>|t|)
(Intercept)	-6.993e-02	-2.461	0.0254 *	-2.652e-02	-0.656	0.515
pwise speechrate	**2.608e-01**	**41.592**	**< 2e-16 *****	**2.181e-01**	**38.717**	**< 2e-16 ***
function_wd	**2.777e-02**	**1.962**	**0.0500 ***	**1.597e-02**	**1.367**	**0.172**
medial position	-5.454e-03	-0.720	0.4717	-2.366e-03	-0.361	0.718
stressed syllable	**4.353e-02**	**6.259**	**4.04e-10 ***	**3.162e-02**	**5.205**	**1.99e-07 ***
log_wd_freq	-4.822e-03	-0.963	0.3361	-2.404e-03	-0.593	0.554
relative_int_diff				**-2.010e-02**	**-58.638**	**< 2e-16 ***

But, the correlation is opposite to expected
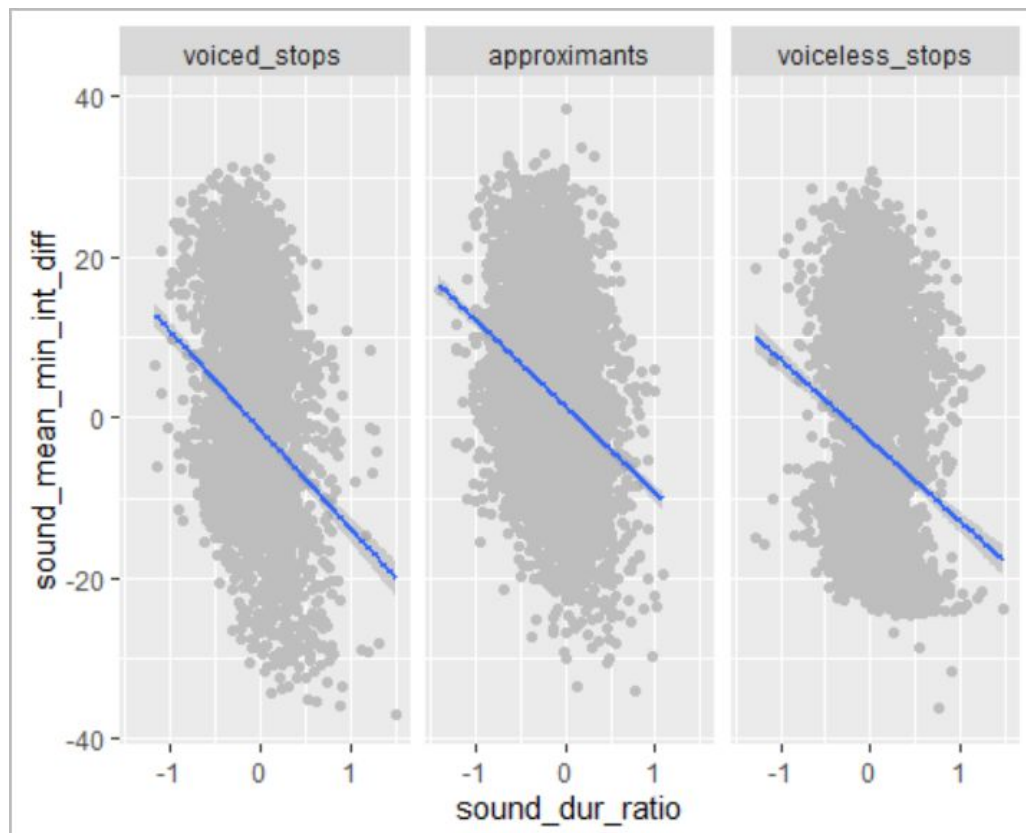
Conclusions:

in the Spanish corpus

the relationship between

duration and intensity

does not seem to be causal

Possible interpretations:

- ❏ different types of segments/lenition changes
- ❏ duration annotation (but separate analyses show similar results)
- ❏ sensitivity to the way variables are calculated and interpreted
- ❏ prosody may be a confounding factor (clitics)

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Thank you!

Slides and publications at www.karolinabros.eu