Motion capture evidence for containment in Spanish stop lenition

Karolina Broś (k.bros@uw.edu.pl) &
Peter A. Krause (peter.krause@csuci.edu)

University of Warsaw & CSU Channel Islands

Background

- /b d g/ are weakened after non-nasal consonants in Spanish
- an allophonic rule (Harris 1969, Mascaró 1984)
- phonetic studies on different dialects provide contradictory evidence
- weakening limited or blocked, especially after /s/ (Amastae 1989, Eddington 2011)

Spanish spoken on Gran Canaria

Both /p t k/ and /b d g/ weaken

/b d g/ approximantise or delete **(only?)** postvocalically

/p t k/ voice or approximantise **only** postvocalically

Spanish spoken on Gran Canaria

What happens to /b d g/ after consonants other that nasals or /l/?

Obscured by widespread consonant **elisions**

Blocking effect in derived postvocalic positions

The percentage of lenited forms in post-deletion contexts is very limited

Examples

UR	Example	Majority realization	Other realizations
/p/	*la paciencia* 'the patience'	[la.**b̥**a.ˈsjen.sja]	[la.**p**a.ˈsjen.sja], [la.**b**a.ˈsjen.sja], [la.**β**a.ˈsjen.sja]
/p/	*Las Palmas*	[la.ˈ**p**almah]	[la.ˈ**b̥**almah], [la.ˈ**b**almah]
/b/	*la barrera* 'the wall'	[la.**β̞**a.ˈre.ɾa]	[la.**β**a.ˈre.ɾa], [la:.ˈre.ɾa]
/b/	*las vacas* *'the cows'*	[la.ˈ**b**a.kah]	[la.ˈ**β**a.kah]

But the /s/ is not always deleted!

Implications of optional /s/ elision

Possible triplets:

1. *la vaca* 'the cow' /la#baka/	UR VCV	/b/ lenition
2. *las vacas* 'the cows' /las#bakas/	/s/ deletion	(no) /b/ lenition
3. *las vacas* 'the cows' /las#bakas/	/s/ retention	/b/ **lenition ?**

Are 2 and 3 different?

Containment?

- **If lenition is blocked both after a deleted and after a retained /s/:**

evidence against post-consonantal weakening in the dialect

- **If the same kind of blocking:**

evidence for non-deletion / non-pronunciation of the /s/

The present study

Motion capture:

- video recordings using internet camera for lip movement exploration
- 15 speakers from Gran Canaria aged 24-55
- we tested labials /p b/ and their surface realisations ([p b b̥ β β̞])
- 376 sentences with 560 target words
- conditions: **deletion (VsCV), no deletion (VCV)**
- flanking vowels were always /a/

Examples of sentences used

La barrera estaba mal colocada y el portero no veía. US /b/

'The wall was incorrectly placed, and the goalkeeper could not see'

La paciencia de esa mujer me tenía impresionado. US /p/

'The patience of this woman had me impressed'

La vaca de Juan cuesta **mucha pasta**. S /b/, SF /p/

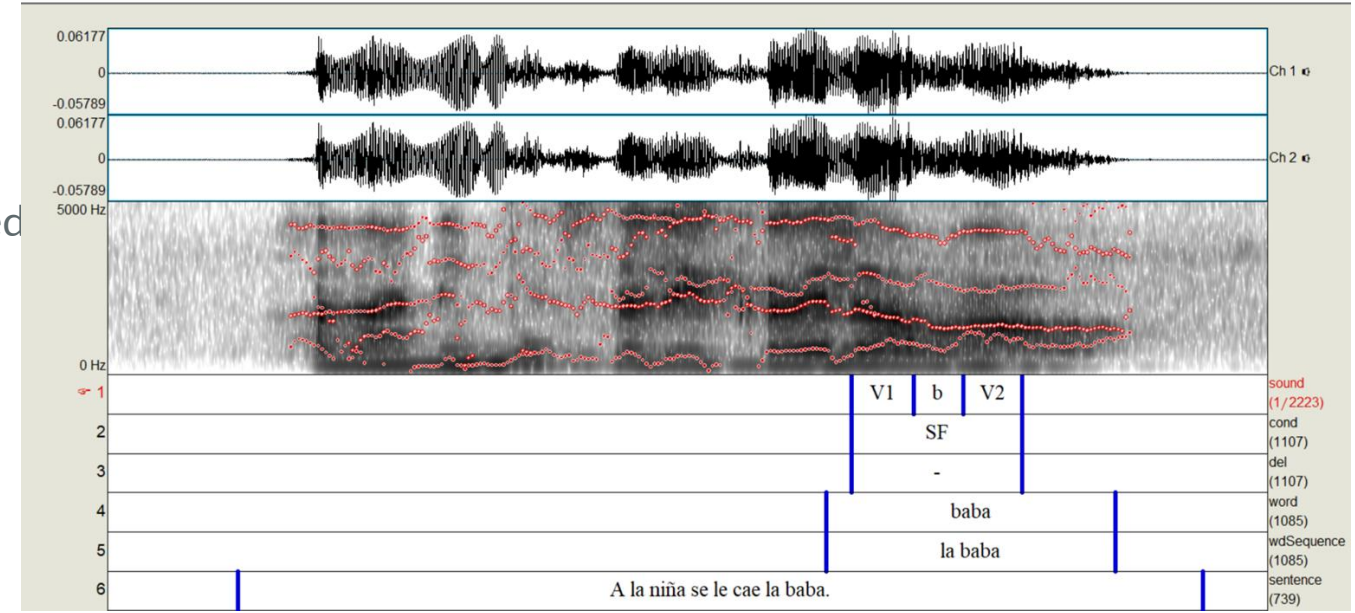
'Juan's cow costs a lot of money'

Las Vacas Locas es una banda de música de Tenerife. DEL /b/

'The Mad Cows is a music band from Tenerife'

Data extraction and video output analysis

Temporal marks for the target words and their critical VCV segment sequences were annotated to Praat TextGrids

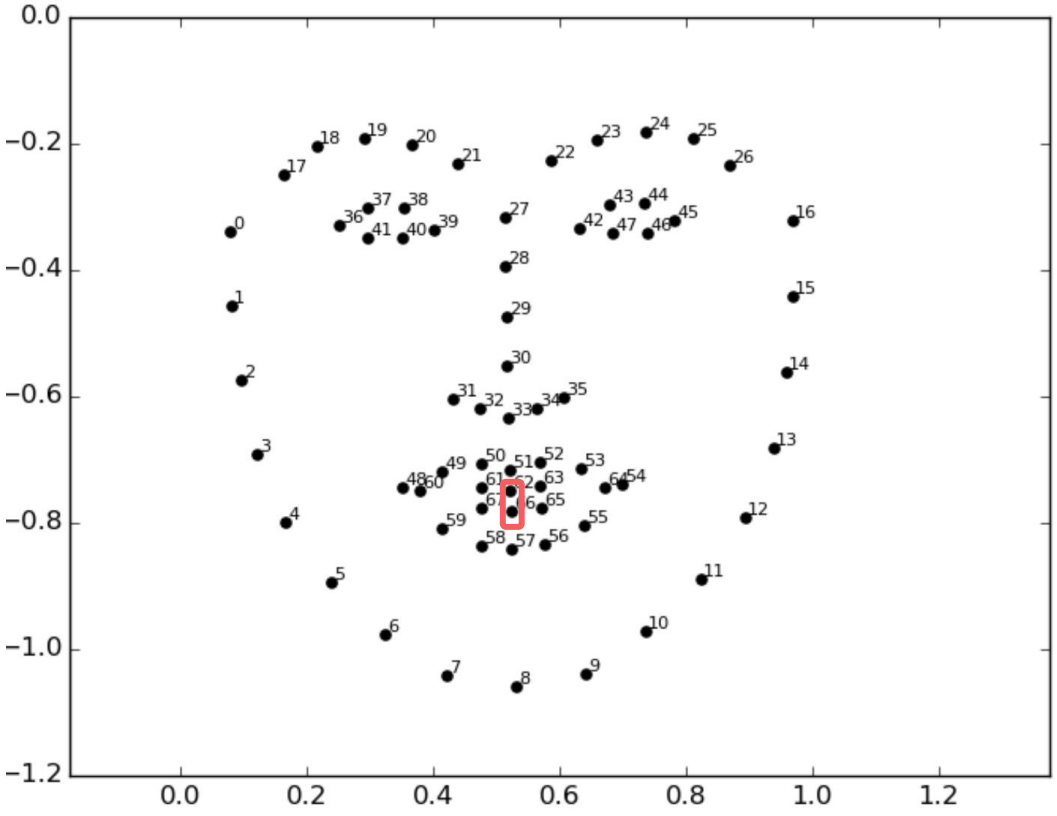


Data extraction and video output analysis

- A custom Python script used these temporal markings as the basis for splitting each participant's video into segments containing just the VCV sequences
- Each video segment was then processed through the OpenFace 2.0 face-tracking utility (Baltrušaitis et al., 2018) - see following examples

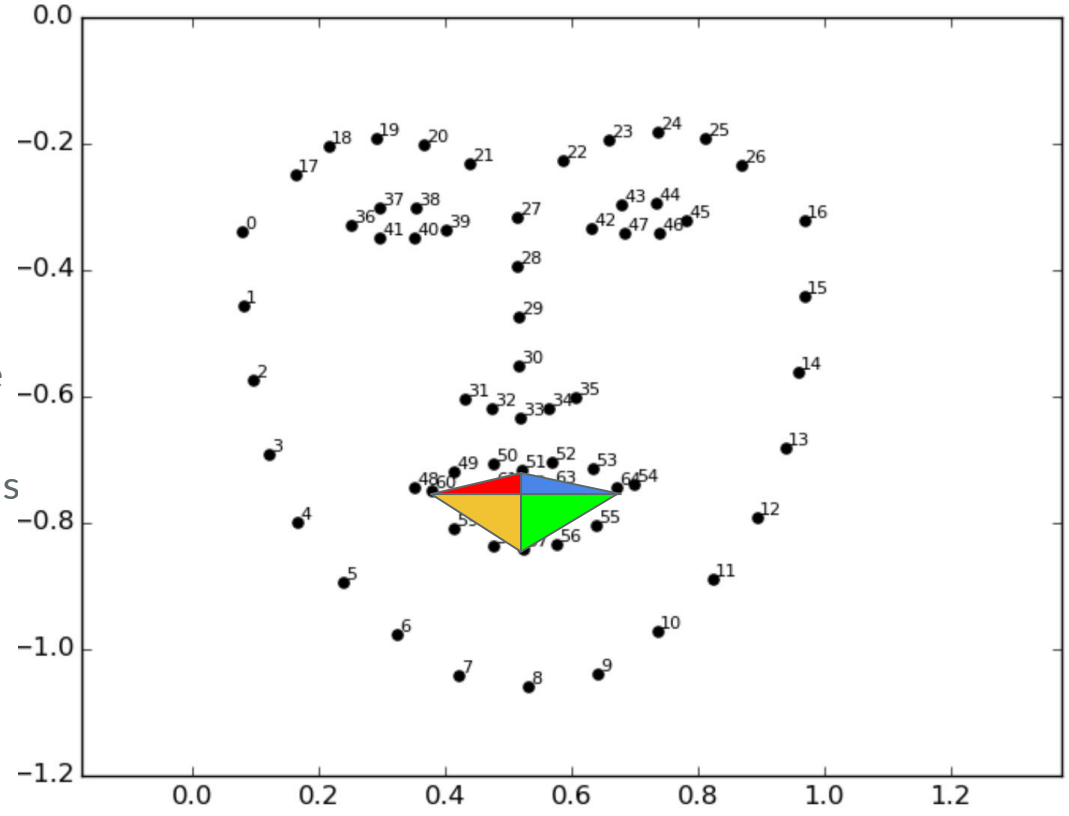
Data extraction and video output analysis

- For each frame of each trial, a custom Python script determined…
  - **Vertical Lip Aperture -** euclidean distance here

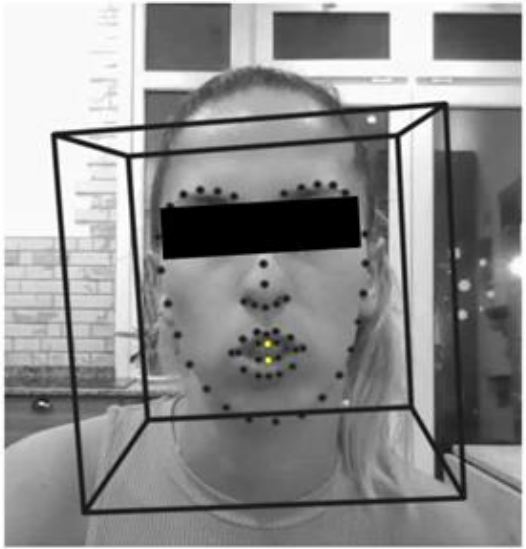


Data extraction and video output analysis

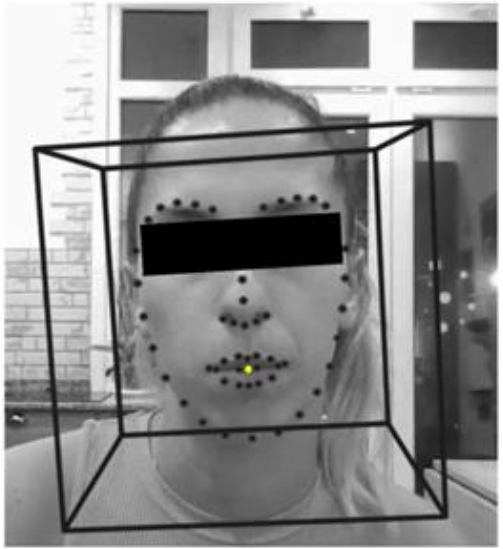
- For each frame of each trial, a custom Python script determined...
  - **Vertical Lip Aperture** - euclidean distance here
  - **Lip Area** - areas of these triangles (plus central rectangle, which here has area 0)



Data extraction: lip aperture



/a/



/p/

Key parameters

- **Vertical lip aperture** calculated as the Euclidean distance between the upper and the lower lip
- **Vertical lip aperture trajectory**, normalized to 11 time steps via linear interpolation
- **Lip area trajectory**, normalized to 11 time steps via linear interpolation
- **Intensity difference** (V1 maximum intensity – C minimum intensity)

The idea

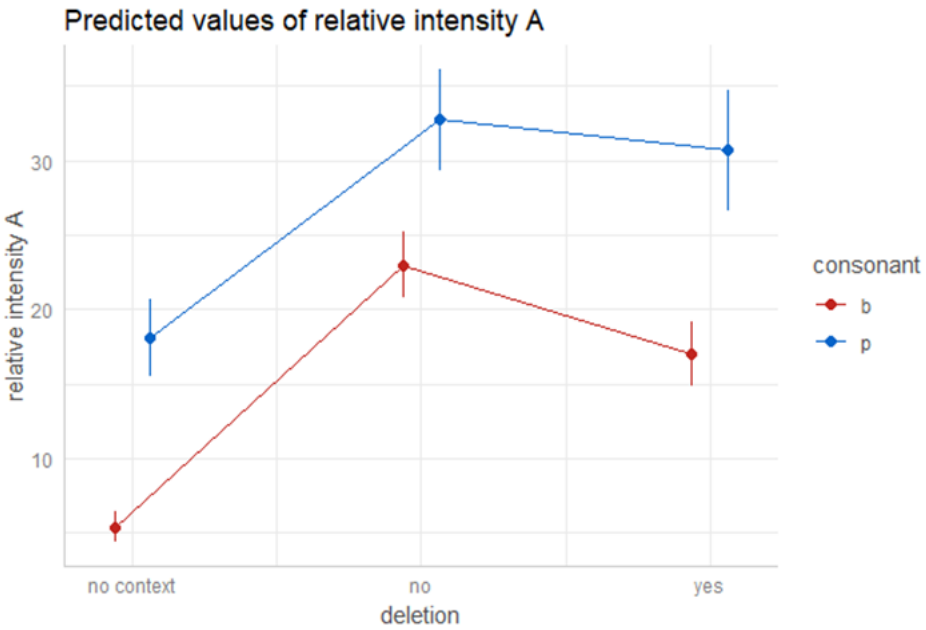
- use lip aperture during consonant closure as a proxy of degree of lenition

- compare those measurements with the acoustics

Assumptions

- ❑ more lenition in VCV than VsCV contexts
- ❑ native speakers either retain /s/ in the form of [h] or delete it in VsCV
- ❑ deleted /s/ opaquely blocks lenition in both /p/ and /b/

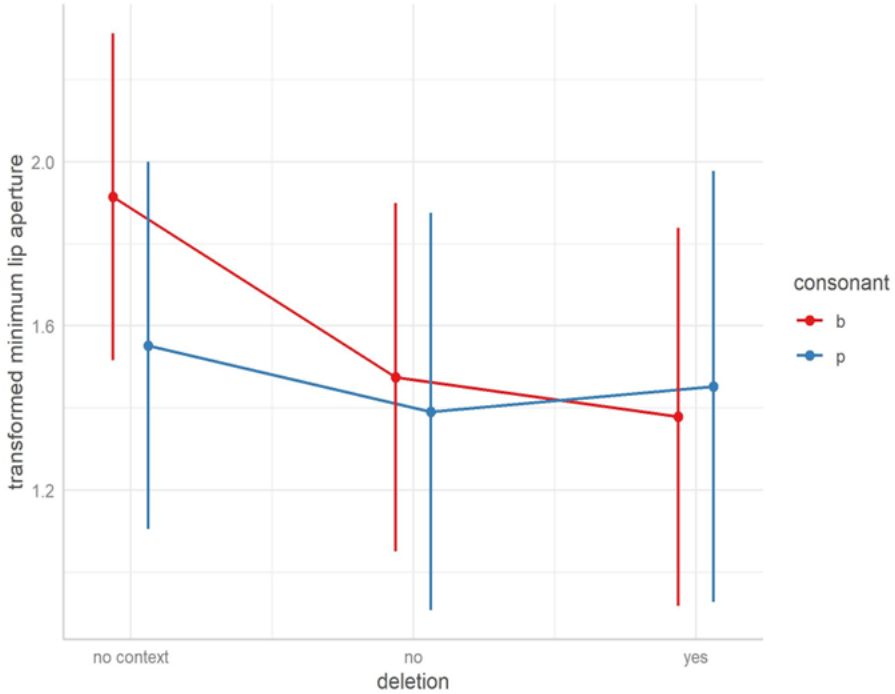
Results: acoustics



Interaction between consonant and deletion context in predicting relative intensity.

The difference between retained and deleted /s/ is significant in /b/ but not /p/.

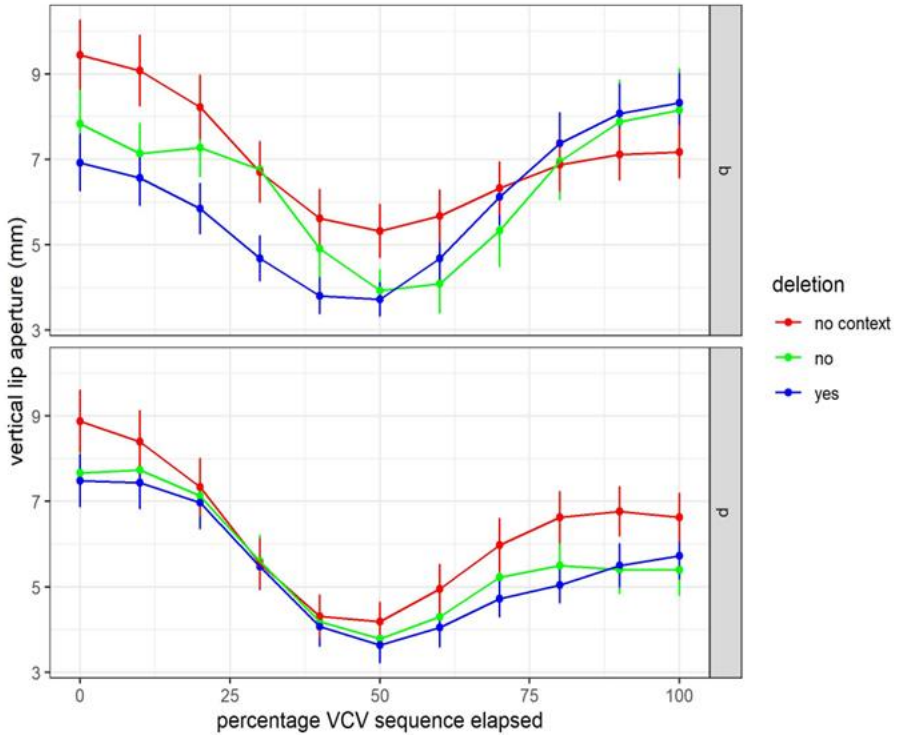
Results: articulation



Effects plot, based on the estimated marginal means of the mixed-effects model, of the interaction between consonant and deletion context in predicting minimum lip aperture.

There is no significant difference between retained and deleted /s/.

Results: mean vertical lip aperture



Vertical lip aperture trajectories (raw means time-normalized to 11 time steps.

Minimum lip aperture does not differ between retained and deleted /s/, although the starting point and timing of the drop do differ.

Interpretation of the results

- articulatory data are compatible with the acoustics: more lenition in underlying VCV compared to the deletion contexts
- derived [VCV] sequences behave like [VsCV] (as if deletion never occurred)
- no obstruent weakening after /s/ in this variety of Spanish

Interpretation of the results

- non-deletion or non-pronunciation of the consonant (Prince & Smolensky 1993, Goldrick 1998, van Oostendorp 2006)

- the root node of the consonant is still there phonologically, hence lack of weakening

Interpretation of the results

- non-deletion or non-pronunciation of the consonant (Prince & Smolensky 1993, Goldrick 1998, van Oostendorp 2006)

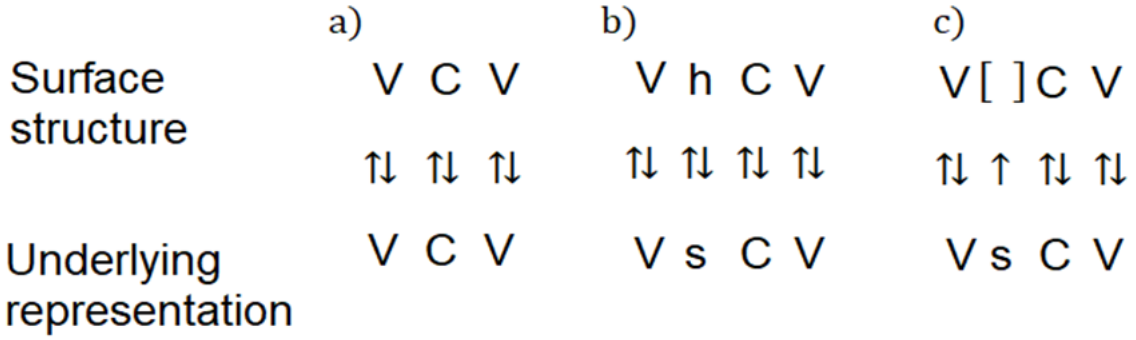
- the root node of the consonant is still there phonologically, hence lack of weakening

HOW?

- a consonantal gesture can still be present despite the fact that the sound is not audible

- gestural masking (?) – two gestures from two different tiers may sometimes mask each other, leading to apparent deletion (Browman & Goldstein 1990)

Interpretation of the results



Possible analysis

*C]Coda: consonants are banned in coda position

*V [−cont, −voice]: voiceless non-continuants are banned after vowels

IDENT(voice): input value of the feature voice must be preserved in the output

Failed evaluation of pensar tonterías *'thinking about silly things'*

/pensar tonterias/	*V [−cont,−v]	*C]CODA	IDENT (voice)	MAX (Seg)
a. pen.sár.ton.te.rí.a		*!		
☹ b. pen.sá.ton.te.rí.a	*!			*
c. pen.sá.don.te.rí.a			*	*

Containment – revision of constraint formulations

PARSE-φ(α): The morphological element must be incorporated into the phonological structure. (No deletion.)

PARSE-μ(α): The phonological element must be incorporated into the morphological structure. (No insertion.)

Containment – revision of constraint formulations

- *V [-cont, -voice]: **voiceless** non-continuants are not pronounced after vowels
- **IDENT(voice):** the input value of the feature voice must be **pronounced** in the output
- **MAXSeg = RECIPROCITY(Rt):** the input root node must be incorporated in the output structure (**projected = pronounced**)

Reanalysis

Successful evaluation of pensar tonterías *'thinking about silly things'*

/pensar tonterias/	*V [−cont,−v]	*C]CODA	IDENT (voice)	MAX (Seg)
a. pen.sa[r_{pp}].ton.te.rí.a[s_{pu}]		*!		*
b. pen.sa[r_{pu}].don.te.ría[s_{pu}]			*!	**
☞ c. pen.sa[r_{pu}].ton.te.rí.a[s_{pu}]				**

Reanalysis – *la(s) vaca(s)*

/la baka/	*V[-cont]	*C]Coda	Ident(cont)	Max(seg)
a. la.baka	*!			
→ b. la.βaka			*	

/las bakas/	*V[-cont]	*C]Coda	Ident(cont)	Max(seg)
a. la[s_{pu}].βaka[s_{pu}]			*!	**
→ b. la[s_{pu}].ba.ka[s_{pu}]				**
c. la[s_{pp}].βa.ka[s_{pp}]		**	*!	
→ d. la[s_{pp}].ba.ka[s_{pp}]		**		

Conclusions

The data:

confirm the blocking effect of deletion

show that there is **no obstruent weakening after /s/**

show **different lenition patterns for voiced vs. voiceless** (in line with differences in the advancement of lenition)

show an **opacity** effect: **consonant not deleted completely**

support containment-based approaches

Conclusions

The study:

provides a novel, cost-effective way of exploring the phonetics and phonology of **consonant lenition**

Outstanding points

- ❏ **an intermediate category** in deletion contexts?
- ❏ variation > change > implications?

Thank you!

Slides and publications at www.karolinabros.eu