Prosodic structure mediates voiced stop lenition in Colombian heritage Spanish

Claire Julia Lozano, Macalester College <clozano@macalester.edu>
Travis G. Bradley, UC Davis <tgbradley@ucdavis.edu>

The 52nd Linguistic Symposium on Romance Languages
University of Wisconsin-Madison – April 22, 2022

1. Introduction

(1) a. Recent research on Spanish bilinguals in the U.S. context has brought a sharper empirical focus on the sound system of heritage Spanish (see Rao 2020, Rao & Ronquest 2015, Ronquest & Rao 2018).
b. Studies of voiced stop lenition in bilingual U.S. Spanish include heritage speakers (Rao 2014, 2015, Blair & Lease 2021), L2 learners (Alvord & Christiansen 2012, Cabrelli Amaro 2017, Díaz-Campos 2004, Face & Menke 2009, González-Bueno 1995, Rogers & Alvord 2014, Zampini 1994, 1997, 1998), and both groups in comparison (Amengual 2019).
c. Rao (2020) further encourages researchers "to include mainstream generative frameworks such as OT [Optimality Theory] in their work as a way increasing our understanding of the phonological grammars" of heritage Spanish speakers (447).

(2) a. The approximantization of voiced stops is commonly analyzed as stricture assimilation or reduction driven by effort minimization in the speaker's grammar (see Colina 2020, Martínez-Gil 2020 for recent OT accounts).
b. A growing body of work suggests that some types of consonant lenition are perceptually motivated as a strategy for signaling the location of prosodic domain boundaries to the listener (Broś et al. 2021, Harper 2014, Katz 2016, Katz & Fricke 2018, Katz & Moore 2021, Keating, 2006, Kingston 2008).

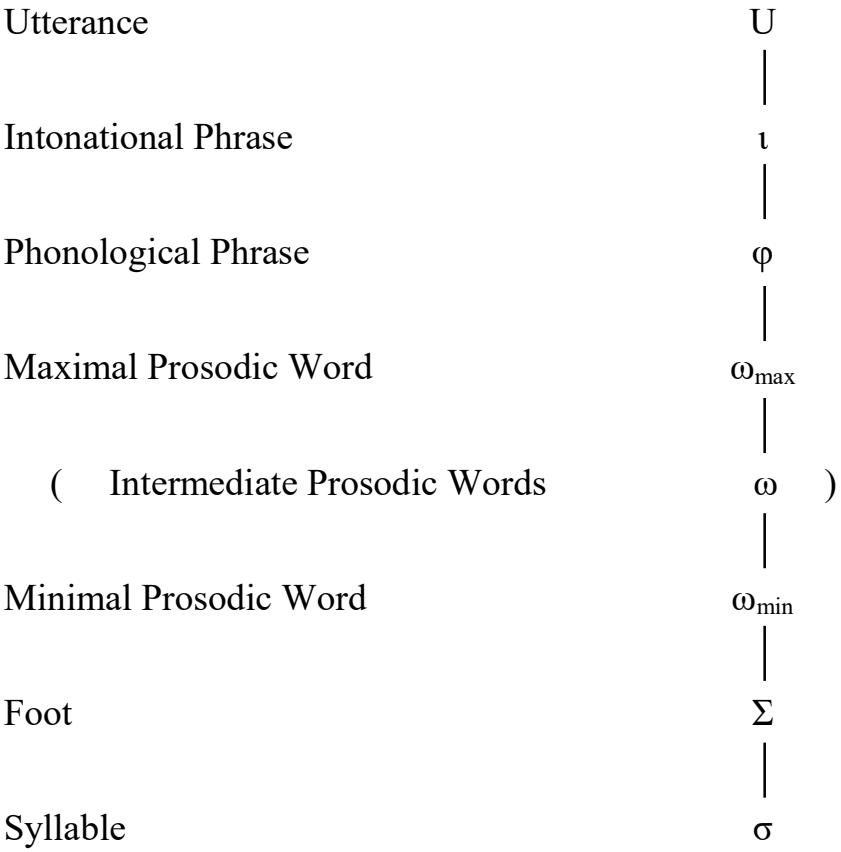
(3) a. Based on experimental production data from Spanish speakers of Colombian heritage, historically the largest immigrant group from South America in the U.S. (Migration Policy Institute 2015), we find evidence that the lenition of intervocalic voiced stops is partially mediated by prosodic structure.
b. Using phonetically based OT, we analyze domain-medial spirantization as *continuity lenition* (Katz 2016), which, in conjunction with fortition at domain edges, helps to demarcate prosodic constituents.
c. We explore the typological predictions of the analysis.

2. Intervocalic voiced stop lenition in Colombian heritage Spanish

Lozano, Claire J. 2021. *Prosodically driven continuity lenition: A phonological account of spirantization in Colombian heritage Spanish.* Ph.D. dissertation. University of California, Davis. Available at https://escholarship.org/uc/item/6jj5n8h5

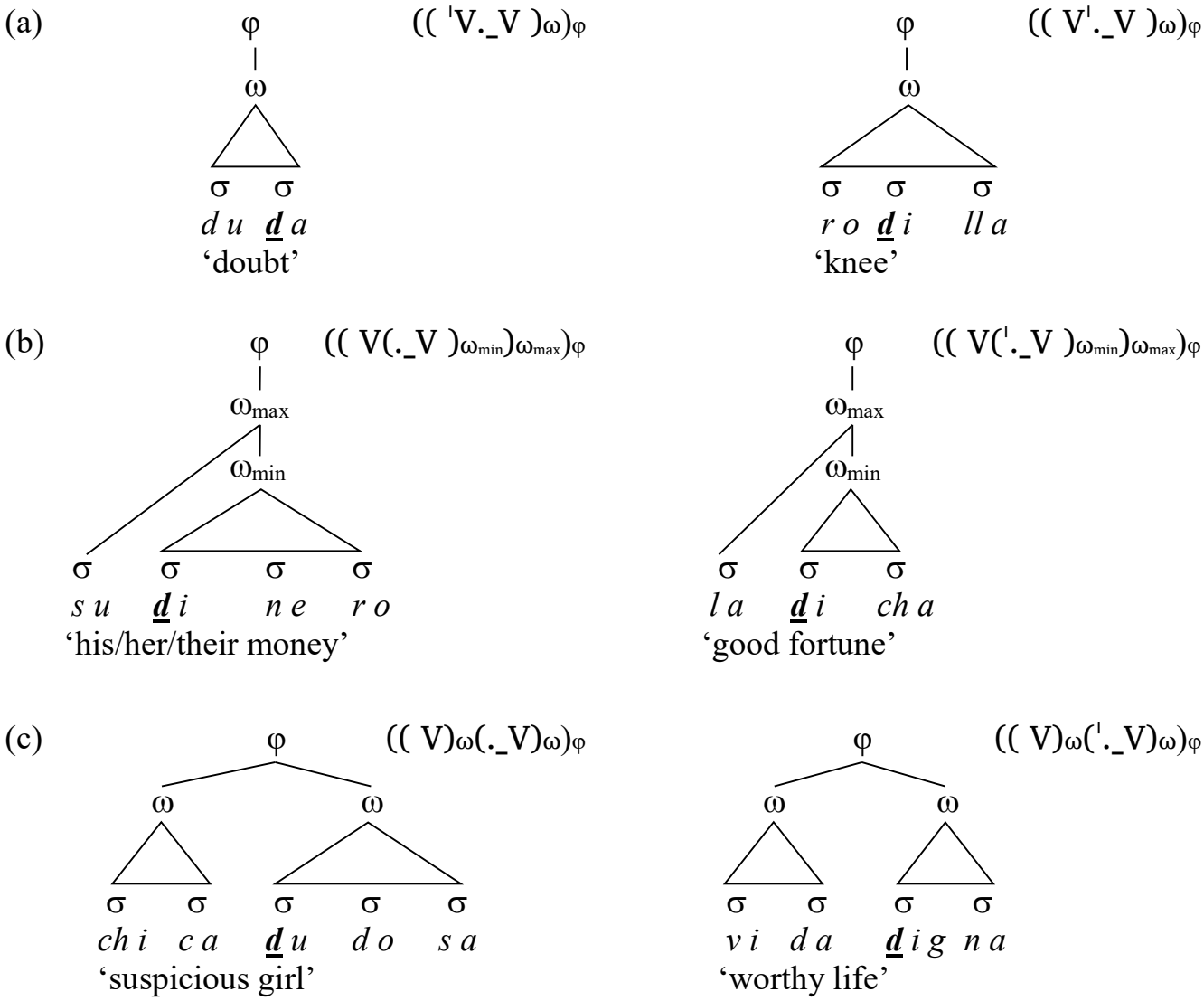
(4) a. How do U.S. Spanish speakers of Colombian heritage produce intervocalic voiced stops (/b, d, g/)?
b. How does their pronunciation of intervocalic voiced stops vary as a function of the following variables: phoneme, syllable stress, prosodic domain, and task type?
c. This talk focuses on prosodic effects. See Lozano (2021) for full details.

Figure 1 Domains of the prosodic hierarchy



(adapted from Bonet 2020: 333; also see Ito & Mester 2007, 2009a,b, Nespor & Vogel 1986, Selkirk 1978, 1984, 1986)

Figure 2 Intervocalic voiced stops in unstressed (left) and stressed (right) syllables within the prosodic word (a) and in initial position of minimal (b) and maximal (c) prosodic words



(5) a. Following Rao (2014, 2015) and Blair & Lease (2021), tokens were classified by audiovisual inspection of VCV sequences in Praat, based on the intensity difference between the minimum dB value of C and the maximum dB value of the following V.

b. Following Rao (2015: 55), we assume three dependent variable categories, illustrated here with the example phrase *lo básico* ‘the basics’: Pure Approximant (Figure 3), Tense Approximant (Figure 4), and Stop (Figure 5).

Figure 3 Pure Approximant (PA) [β̞]: 2-4 dB intensity difference between V_2 maximum and C minimum

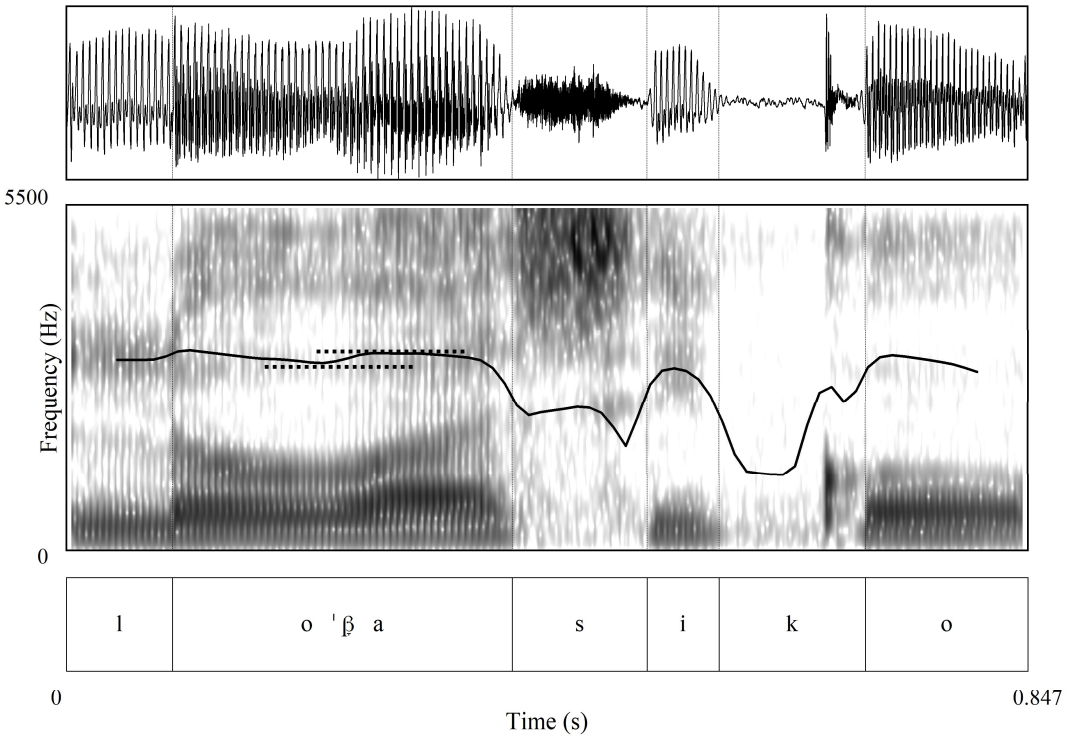


Figure 4 Tense Approximant (TA) [ḅ]: >5 dB intensity difference between V_2 maximum and C minimum

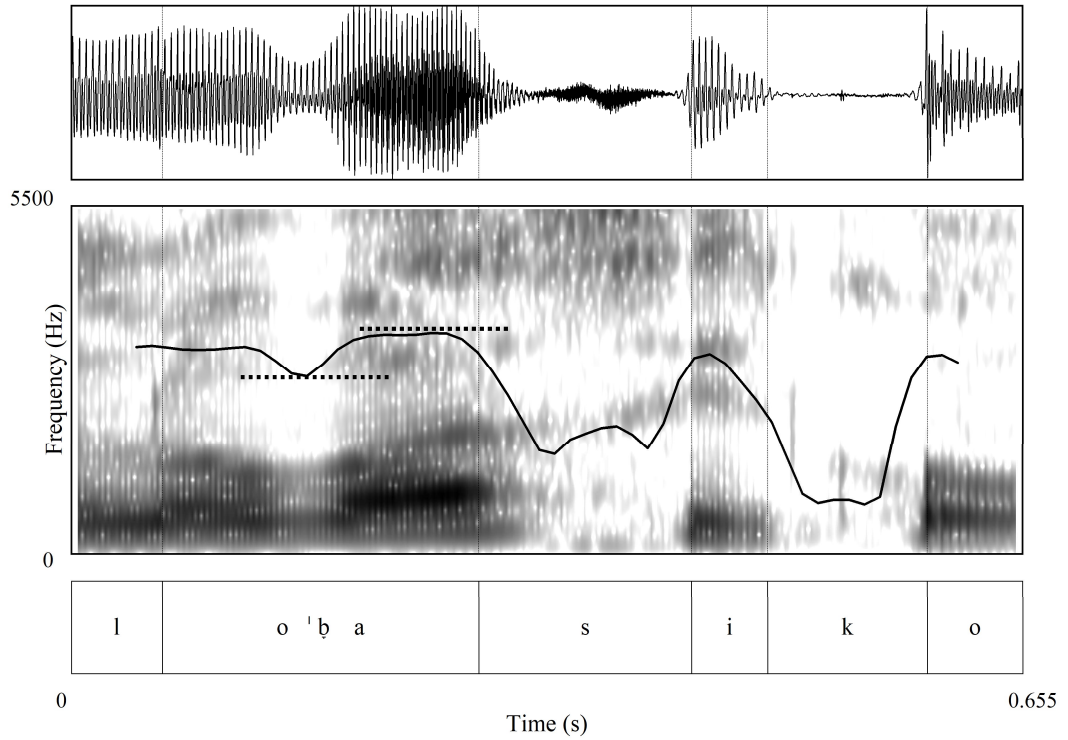
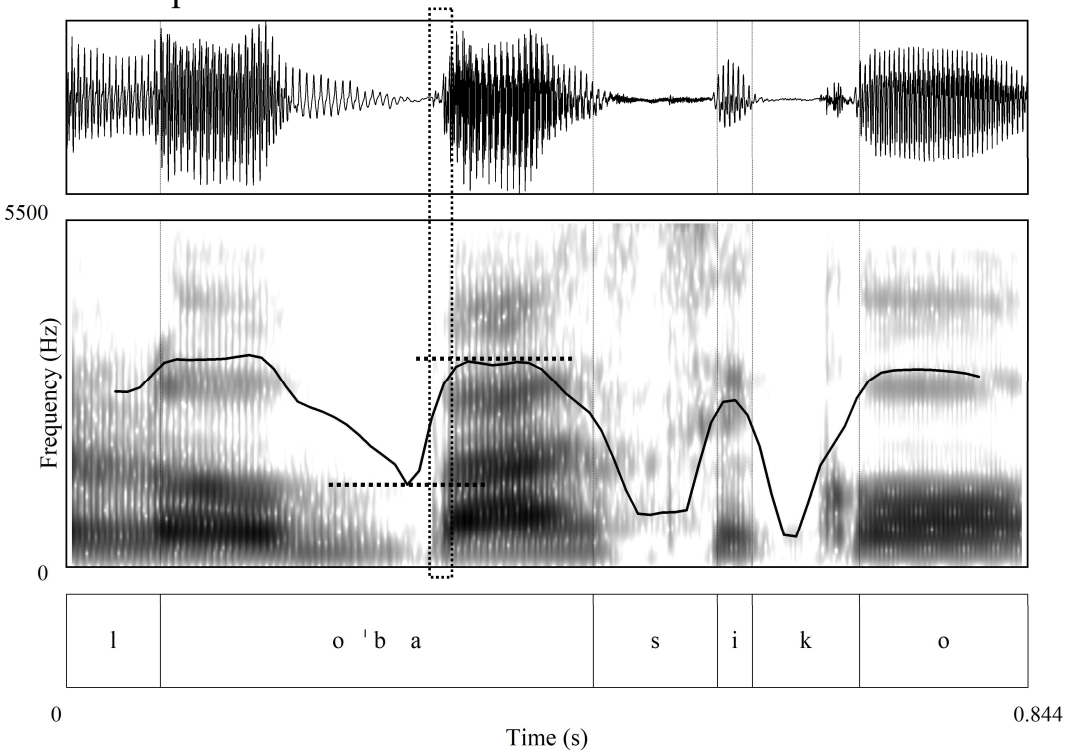


Figure 5 Stop [b]: >5 dB intensity difference between V_2 maximum and C minimum, and presence of stop release burst



(6) a. Most studies of monolingual Spanish varieties distinguish between word-medial and word-initial positions, where the latter is explicitly defined as excluding any intervening pause (Broś et al. 2021, Carrasco 2008, Carrasco et al. 2012, Eddington 2011). Word-medial position is generally found to show greater rates and degrees of lenition.

b. Zampini (1997, 1998) hypothesizes that L2 learners acquire voiced stop lenition in a given prosodic domain once they have already acquired it at all lower, more restrictive domains, in accordance with a subset principle.

c. Rao (2015) reports significantly higher rates of PAs in word-medial position and STs in word-initial position among heritage speakers.

d. Explicitly distinguishing between the minimal and maximal projections of the prosodic word (Ito & Mester 2007, 2009a,b), as in Figure 2 (b), Cabrelli Amaro (2017) finds support for the hypothesis that lenition is acquired earlier in lower prosodic domains, although her L2 learners failed to show a difference between minimal and maximal prosodic word domains.

(7) a. A reasonable hypothesis for U.S. Spanish speakers of Colombian heritage is that weaker realizations should be favored in the initial position of smaller prosodic domains and stronger realizations in the initial position of larger domains.

b. Sixteen participants spanning three generations and residing in Florida and New Jersey (see Appendix, Table 7) were recorded in a controlled frame-sentence reading task and a semi-directed conversation dyad.

c. Audio was recorded with a Zoom H4nPro digital recorder at 44,100 Hz with a 16-bit depth. Each participant used a lavalier microphone clipped onto their shirt approximately 4-6 inches away from the talker's mouth.

(8) a. Controlled reading task
- PDF slideshow presentation via iPad
- frame sentence *"Diga ___ una vez."*
- counterbalanced blocks of semi-randomized items (Appendix, Table 8)
- 3 phonemes × 2 stress × 2 items × 3 domains × 2 repetitions × 2 blocks = 144 total items per participant

b. Semi-directed conversation dyad
- paired participants conversed freely for at least 15-25 minutes, with question prompts administered via iPad if needed
- tokens for analysis were taken from the first 25 minutes
- inaudible tokens were eliminated

(9) Examples of tokens (boldfaced) extracted from conversation dyad

María: *Va a ha**b**er un tiempo en que nosotros no—ahí no se pue**d**e hacer na**d**a. Pero yo **d**i**g**o que están haciendo eso en el come**d**or—*

Lollipop: *Oh, sí en el come**d**or, no te **d**ejan XXX*

María: *No. Ahoritica no. Pongamos las clases del miércoles no van a hacer ya ahí van a ser—se lo **d**ijo a la gente i**b**a a ser en otra parte en un salón de esos que está un poco más amplio, pero hay—*

María: 'There will be a time that we [can't]—we can't do anything there. But I'm saying that they're doing this in the cafeteria—'

Lollipop: 'Oh, yes in the cafeteria, they won't let you XXX'

María: 'No. Not right now. We decided not to do the Wednesday classes there—they told people it would be in another area in one of those rooms that's a little bigger but there's—'

Table 1 Summary of token distribution by independent variable

Variable	Context	Tokens	PA	TA	Stop
Phoneme	/b/	1217	59.41%	28.18%	12.41%
	/d/	1679	68.31%	15.49%	16.20%
	/g/	1112	20.77%	45.95%	33.27%
Syllable Stress	Stressed	1862	43.77%	32.81%	23.42%
	Unstressed	2146	59.93%	23.44%	16.64%
Prosodic Domain	Syllable	2010	65.87%	24.98%	9.15%
	PW-min	1129	42.43%	32.42%	25.16%
	PW-max	869	34.29%	28.31%	37.40%
Task	Reading	2281	32.70%	36.34%	30.95%
	Conversation	1727	78.46%	16.50%	5.04%

Table 2 Distribution of tokens by participant across dependent variable categories

Participant	Location	Tokens	PA	TA	Stop
María	FL	344	54.07%	29.36%	16.57%
Lollipop	FL	332	63.86%	29.52%	6.63%
MommaKat	FL	238	51.68%	42.02%	6.30%
Carmen	FL	318	57.23%	25.16%	17.61%
Dalia	FL	301	65.78%	24.25%	9.97%
Andrea	FL	228	71.93%	10.53%	17.54%
Lola	FL	147	25.85%	61.90%	12.24%
Liliana	FL	143	0.70%	34.97%	64.34%
Sergio	FL	232	73.28%	14.22%	12.50%
Marby	NJ	310	47.74%	18.06%	34.19%
Janine	NJ	409	50.37%	29.10%	20.54%
Mariela	NJ	232	56.03%	27.59%	16.38%
Esperanza	NJ	185	59.46%	35.68%	4.86%
Katrina	NJ	225	48.00%	34.22%	17.78%
Maximos	NJ	164	10.37%	18.90%	70.73%
Victor	NJ	200	54.00%	25.50%	20.50%

Table 3 Descriptive statistics for task type

Task		**PA**	**TA**	**Stop**
Reading	n	746	829	706
	Mean tokens per participant	46.625	51.8125	44.125
	Standard Error	7.39418409	4.84872728	7.41050774
	Standard Deviation	29.5767364	19.3949091	29.642031
	Sample Variance	874.783333	376.1625	878.65
Conversation	n	1355	285	87
	Mean tokens per participant	84.6875	17.8125	5.4375
	Standard Error	15.3418596	3.79277685	1.4170649
	Standard Deviation	61.3674384	15.1711074	5.66825958
	Sample Variance	3765.9625	230.1625	32.1291667

(10) a. Generalized linear mixed-effects regression models, using the *glmer* function within the package *lme4* (Bates et al. 2015), were run for each of the dependent variables, including a random intercept for participant.

b. Each model of PA, TA, and Stop had fixed effects for the factorial combinations of phoneme, prosodic domain, stress, and task, as presented in Table 4 (statistically significant differences, at alpha level .05, are indicated by an asterisk).[1]

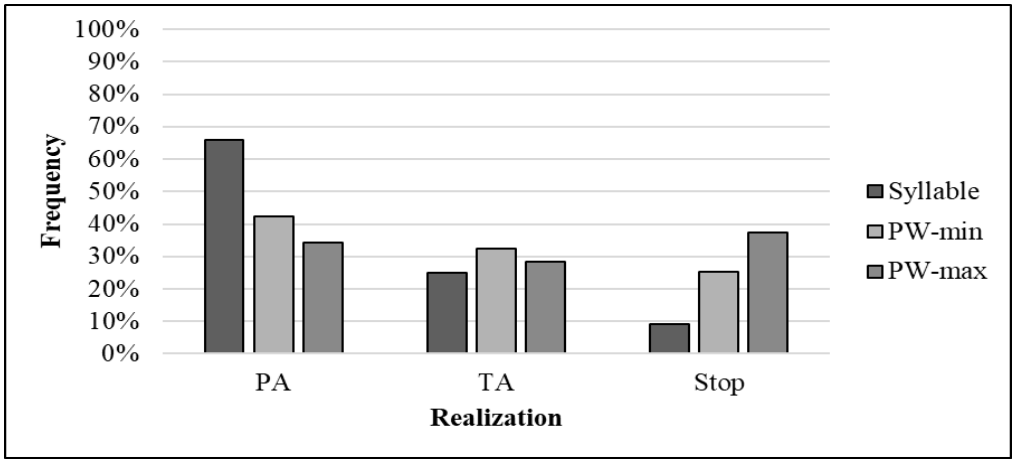
c. See Lozano (2021) for further details about significant interactions among independent variables, most of which were found for the PA and TA models.

[1] The low rate of Stops throughout the data set led to convergence errors while running the Stop model for main effects. The individual variability in token production in the conversation task also led to issues evaluating the results for participants with fewer tokens.

Table 4 Main effects

Model	Effect	Standard Error	p
PA	/b/ vs. /d/	0.143	0.1125
	/b/ vs. /g/	0.530	<.0001*
	/d/ vs. /g/	0.518	<.0001*
	PW-max vs. PW-min	**0.530**	**0.0230***
	PW-max vs. Syllable	**0.517**	**0.0009***
	PW-min vs. Syllable	**0.138**	**0.0019***
	Stress	0.341	0.0005*
	Task	0.355	<.0001*
TA	/b/ vs. /d/	1.559	0.5015
	/b/ vs. /g/	0.663	0.0028*
	/d/ vs. /g/	1.399	0.0136*
	PW-max vs. PW-min	**1.402**	**0.2325**
	PW-max vs. Syllable	**0.653**	**0.1455**
	PW-min vs. Syllable	**1.552**	**0.7729**
	Stress	0.938	0.0363*
	Task	1.28	0.5671
Stop	/b/ vs. /d/	137	0.9998
	/b/ vs. /g/	642	1.0000
	/d/ vs. /g/	627	1.0000
	PW-max vs. PW-min	**640**	**1.0000**
	PW-max vs. Syllable	**629**	**1.0000**
	PW-min vs. Syllable	**137**	**1.0000**
	Stress	428	0.9997
	Task	428	0.9904

Figure 6 Prosodic domain effects



(11) a. Pair-wise comparisons reveal significant differences among each of the three contexts, but only for PAs: frequency decreases as the preceding boundary becomes higher in the prosodic hierarchy, **syllable > PW-min > PW-max.**

b. There is no main effect on either TA or Stop frequency, as the differences among prosodic domains are not statistically significant.

c. Stops trended in the opposite direction from PAs, becoming more frequent across higher boundaries (**PW-max > PW-min > syllable**), with TAs occupying the middle ground.

d. For effects of the other independent variables on allophone frequencies, see Appendix, Figure 9 (phoneme), Figure 10 (stress), and Figure 11 (task type).

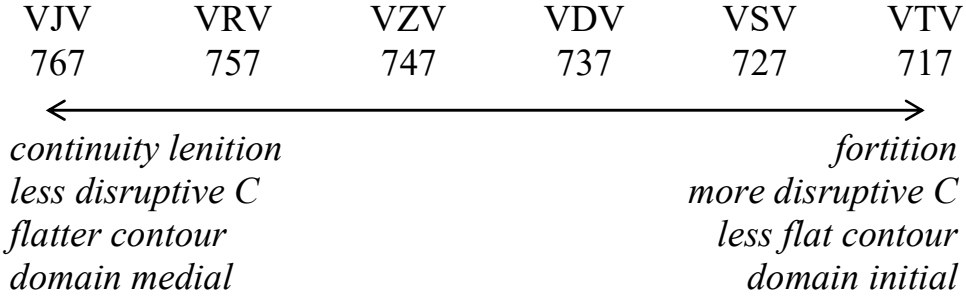
3. Prosodic structure, continuity lenition, and boundary disruption

(12) BOUNDARY-DISRUPTION(*I,D,P*) (Katz 2016: 56)
Intensity drops to amount *I* or lower for at least duration *D at and only at* a prosodic boundary of level *P*.

Table 5 Alignment of Rao's (2015) dependent variable categories PA, TA, and voiced Stop to Katz's (2016: 57) scale of relative consonantal intensity

relative consonantal intensity (Katz 2016)				dependent variable categories (Rao 2015)	
J	glide	6			
R	tap	5	←	PA	β̪, ð̪, ɣ̪
Z	voiced continuant	4	←	TA	b̪, d̪, g̪
D	voiced stop	3	←	Stop	b, d, g
S	voiceless continuant	2			
T	voiceless stop	1			

Figure 7 Ranking of VCV intensity contours by relative flatness



(13) INTENSITY≤n_{DOMAIN} (Lozano 2021: 155)
Assign a violation for
a. every consonant of intensity ≤*n* that is not edge-adjacent in a prosodic DOMAIN
b. every edge-adjacent consonant in a prosodic DOMAIN that is not of intensity ≤*n*

(14) a. Stringency hierarchy (de Lacy 2004) of constraints governing the distribution of intensity values 3 (TA) and 4 (Stops) in three prosodic domains:
b. INTENSITY≤3φ INTENSITY≤3ω_{max} INTENSITY≤3ω_{min}
INTENSITY≤4φ INTENSITY≤4ω_{max} INTENSITY≤4ω_{min}

(15) a. *PA
Assign a violation for every pure approximant [β̪, ð̪, ɣ].
b. *TA
Assign a violation for every tense approximant [b̪, d̪, g̪].

(16)

Grammar #5 (see Table 6)	INT≤3 ω_{max}	INT≤4 ω_{min}	*PA	*TA
☞ a. (((du.ð̪a)ω$_{min}$)ω$_{max}$)φ 7 57			*	
b. (((du.d̪a)ω$_{min}$)ω$_{max}$)φ 7 47		*!		*
c. (((du.da)ω$_{min}$)ω$_{max}$)φ 7 37	*(!)	*(!)		
d. (((su(.ð̪i.ne.ɾo)ω$_{min}$)ω$_{max}$)φ 7 57		*!	*	
☞ e. (((su(.d̪i.ne.ɾo)ω$_{min}$)ω$_{max}$)φ 7 47				*
f. (((su(.di.ne.ɾo)ω$_{min}$)ω$_{max}$)φ 7 37	*!			
h. (((ʧi.ka)ω$_{min}$)ω$_{max}$((.ð̪u.ð̪o.sa)ω$_{min}$)ω$_{max}$)φ 7 57	*(!)	*(!)	*	
i. (((ʧi.ka)ω$_{min}$)ω$_{max}$((.d̪u.ð̪o.sa)ω$_{min}$)ω$_{max}$)φ 7 47	*!			*
☞ j. (((ʧi.ka)ω$_{min}$)ω$_{max}$((.du.ð̪o.sa)ω$_{min}$)ω$_{max}$)φ 7 37				

4. A typology of continuity lenition grammars

(17) a. Using OTSoft (Hayes et al. 2013), we computed the factorial typology of the six INTENSITY constraints in (14b) and the two context-free markedness constraints in (15a,b).

b. From 40,320 logically possible rankings of eight constraints (= 8!), there emerged just ten distinct, maximally simple grammars, each consisting of two ranking strata.

c. Table 6 shows the dominant constraints in each grammar and the distributions they optimize (boldface and darker shading denote greater intensity allophones). PAs occupy the lower left quadrant of the typological space and Stops, the upper right.

d. The overall typology matches up with the effects of prosodic domain on allophone frequency in Figure 6:

Table 6 Factorial typology of continuity lenition across three prosodic domains

	dominant constraints	((V._V)ω_{min})ω_{max}	(V(._V)ω_{min})ω_{max}	((V))ω_{max}((._V))ω_{max}
G1	*PA, *TA	Stop	Stop	Stop
G2	INT≤3ω_{min}, *PA	**TA**	Stop	Stop
G3	INT≤3ω_{min}, INT≤4ω_{min}	**PA**	Stop	Stop
G4	INT≤3ω_{max}, *PA	**TA**	**TA**	Stop
G5	INT≤3ω_{max}, INT≤4ω_{min}	**PA**	**TA**	Stop
G6	INT≤3ω_{max}, INT≤4ω_{max}	**PA**	**PA**	Stop
G7	INT≤3φ, *PA	**TA**	**TA**	**TA**
G8	INT≤3φ, INT≤4ω_{min}	**PA**	**TA**	**TA**
G9	INT≤3φ, INT≤4ω_{max}	**PA**	**PA**	**TA**
G10	INT≤3φ, INT≤4φ	**PA**	**PA**	**PA**

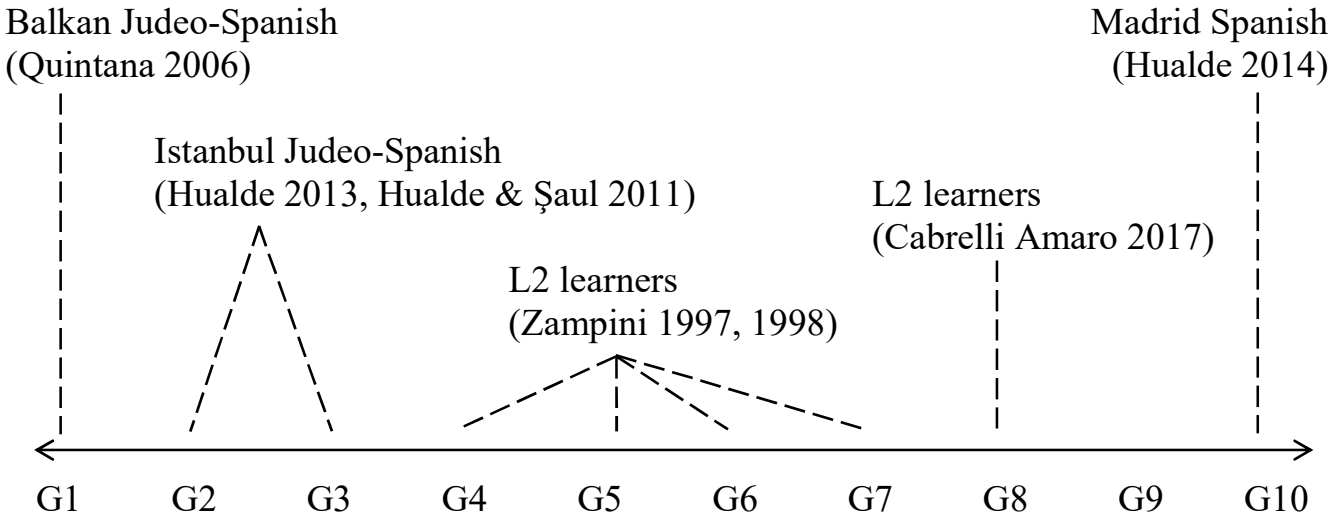
(18)

Grammar #1 (e.g., Balkan Judeo-Spanish)		*PA	*TA	Int≤3φ	Int≤3ω_{max}	Int≤3ω_{min}	Int≤4φ	Int≤4ω_{max}	Int≤4ω_{min}
a. du.ð̞a	757	*!							
b. du.d̞a	747		*!				*	*	*
☞ c. du.da	737			*	*	*	*	*	*
d. su.ð̞i.ne.ɾo	757	*!				*			*
e. su.d̞i.ne.ɾo	747		*!			*	*	*	
☞ f. su.di.ne.ɾo	737			*	*		*	*	
h. ʧi.ka.ð̞u.ð̞o.sa	757	*!			*	*		*	*
i. ʧi.ka.d̞u.ð̞o.sa	747		*!		*	*	*		
☞ j. ʧi.ka.du.ð̞o.sa	737			*			*		

(19)

Grammar #10 (e.g., Madrid Spanish)		Int≤3φ	Int≤4φ	Int≤3ω_{max}	Int≤3ω_{min}	Int≤4ω_{max}	Int≤4ω_{min}	*PA	*TA
☞ a. du.ð̞a	757							*	
b. du.d̞a	747		*!			*	*		*
c. du.da	737	*(!)	*(!)	*	*	*	*		
☞ d. su.ð̞i.ne.ɾo	757				*		*	*	
e. su.d̞i.ne.ɾo	747		*!		*	*			*
f. su.di.ne.ɾo	737	*(!)	*(!)	*		*			
☞ h. ʧi.ka.ð̞u.ð̞o.sa	757			*	*	*	*	*	
i. ʧi.ka.d̞u.ð̞o.sa	747		*!	*	*				*
j. ʧi.ka.du.ð̞o.sa	737	*(!)	*(!)						

Figure 8 Variation along a grammatical continuum of intervocalic voiced stop lenition



(20) a. Cabrelli Amaro (2017) uses positional faithfulness to capture the asymmetry between word-medial vs. word-initial lenition in beginning L2 Spanish learners, as shown in (21).

b. Problem: unless stops are assumed in the input, high-ranking faithfulness to the onset of the prosodic word overgenerates a phonological contrast between word-initial voiced stops (21e) and continuants (21h).

c. Our analysis uses markedness constraints to distinguish between word-medial (22a) and word-initial (22e,i) contexts. Low ranking faithfulness to [continuant] correctly rules out the phonological contrast in Spanish.

(21)

Beginning L2 learners		IDENT (cont) ONSET PW	*VOISST /V_	IDENT (cont) ONSET SYLL	IDENT (cont)	*APPR/ V_
a. /duda/	ˈdu.da		*!			
☞ b.	ˈdu.ð̞a			*	*	*
c. /duð̞a/	ˈdu.da		*!	*	*	
☞ d.	ˈdu.ð̞a					*
☞ e. /ʧika dudosa/	ˈʧi.ka duˈ.ð̞o.sa		*			*
f.	ˈʧi.ka ð̞uˈ.ð̞o.sa	*!		*	*	**
g. /ʧika ð̞udosa/	ˈʧi.ka duˈ.ð̞o.sa	*!	*	*	*	*
☞ h.	ˈʧi.ka ð̞uˈ.ð̞o.sa					**

(22)

Grammar #8 (e.g., L2 learners)			INT≤3φ	INT≤4ω_{min}	INT≤3ω_{max}	INT≤3ω_{min}	INT≤4φ	INT≤4ω_{max}	*PA	*TA
☞	a. du.ð̩a	757							*	
	b. du.d̩a	747		*!			*	*		*
	c. du.da	737	*(!)	*(!)	*	*	*	*		
	d. su.ð̩i.ne.ɾo	757		*!		*			*	
☞	e. su.d̩i.ne.ɾo	747				*	*	*		*
	f. su.di.ne.ɾo	737	*!		*		*	*		
	h. ʧi.ka.ð̩u.ð̩o.sa	757		*!	*	*		*	*	
☞	i. ʧi.ka.d̩u.ð̩o.sa	747			*	*	*			*
	j. ʧi.ka.du.ð̩o.sa	737	*!				*			

5. Conclusion

(23) Main take-aways

a. U.S. Spanish speakers of Colombian heritage in Florida and New Jersey show evidence of prosodically mediated intervocalic voiced stop lenition.

b. We analyze domain-medial spirantization as *continuity lenition* (Katz 2016), which, in conjunction with fortition at domain edges, helps to demarcate prosodic constituents.

c. A typology of continuity lenition grammars generates surface distributions that predict a range of prosodic mediation effects across Spanish varieties.

Appendix

Table 7 Participant demographic summary

Participant (pseudonym)	Age	Gender	Generation (Age of arrival)	Location	Order of Acquisition
María	67	female	1 (17)	FL	Sequential
Lollipop	48	female	2	FL	Sequential
MommaKat	50	female	2	FL	Sequential
Carmen	49	female	2	FL	Sequential
Dalia	20	female	2	FL	Simultaneous
Andrea	19	female	3	FL	Simultaneous
Lola	21	female	3	FL	Simultaneous
Liliana	18	female	3	FL	Simultaneous
Sergio	24	male	3	FL	Simultaneous
Marby	57	female	1 (11)	NJ	Sequential
Janine	60	female	1 (13)	NJ	Sequential
Mariela	51	female	1 (6)	NJ	Sequential
Esperanza	19	female	2	NJ	Simultaneous
Katrina	29	female	2	NJ	Simultaneous
Maximos	18	male	2	NJ	Simultaneous
Victor	26	male	2	NJ	Simultaneous

Table 8 Stimuli used in the controlled frame-sentence reading task

Token	Phoneme	Stress	Syllables	Domain
ca**b**allo	b	stressed	3	syllable
tra**b**ajo	b	stressed	3	syllable
sá**b**ana	b	unstressed	3	syllable
gra**b**adora	b	unstressed	4	syllable
pe**d**azo	d	stressed	3	syllable
agra**d**able	d	stressed	4	syllable
a**d**apción	d	unstressed	3	syllable
na**d**ador	d	unstressed	3	syllable
abo**g**ada	g	stressed	4	syllable
gi**g**ante	g	stressed	3	syllable
hí**g**ado	g	unstressed	3	syllable
obli**g**ación	g	unstressed	4	syllable
mi **b**arrio	b	stressed	4	PWmin
lo **b**ásico	b	stressed	4	PWmin
la **b**allena	b	unstressed	4	PWmin
su **b**andera	b	unstressed	3	PWmin
su **d**ado	d	stressed	3	PWmin
la **d**ama	d	stressed	3	PWmin
lo **d**añino	d	unstressed	4	PWmin
la **d**anesa	d	unstressed	4	PWmin
mi **g**ato	g	stressed	3	PWmin
la **g**ala	g	stressed	3	PWmin
su **g**anancia	g	unstressed	4	PWmin
la **g**allina	g	unstressed	4	PWmin
gana la **b**atalla	b	unstressed	6	PWmin
es un curso **b**ásico	b	stressed	7	PWmax
no tengo **b**arcos	b	stressed	5	PWmax
me quiero **b**ajar	b	unstressed	5	PWmax
necesito **d**arme cuenta	d	stressed	8	PWmax
no veo **d**amas	d	stressed	5	PWmax
no puedo **d**añarme	d	unstressed	6	PWmax
es una linda **d**anesa	d	unstressed	8	PWmax
no tengo **g**anas	g	stressed	5	PWmax
es el mismo **g**ato	g	stressed	6	PWmax
le puede **g**arantizar	g	unstressed	7	PWmax
una buena **g**arantía	g	unstressed	8	PWmax

Figure 9 Phoneme effects

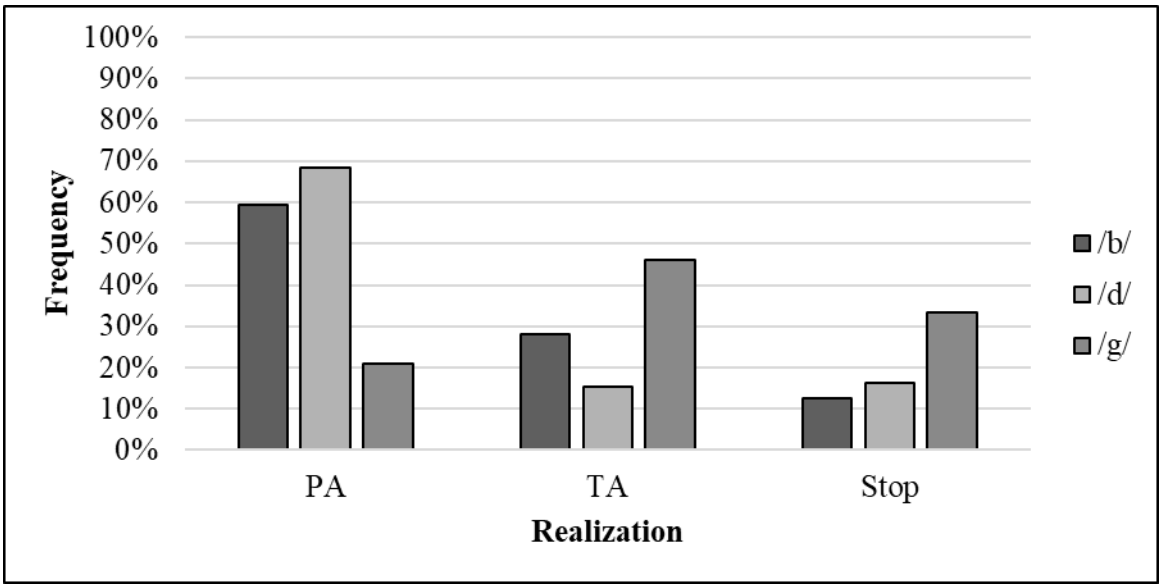


Figure 10 Stress effects

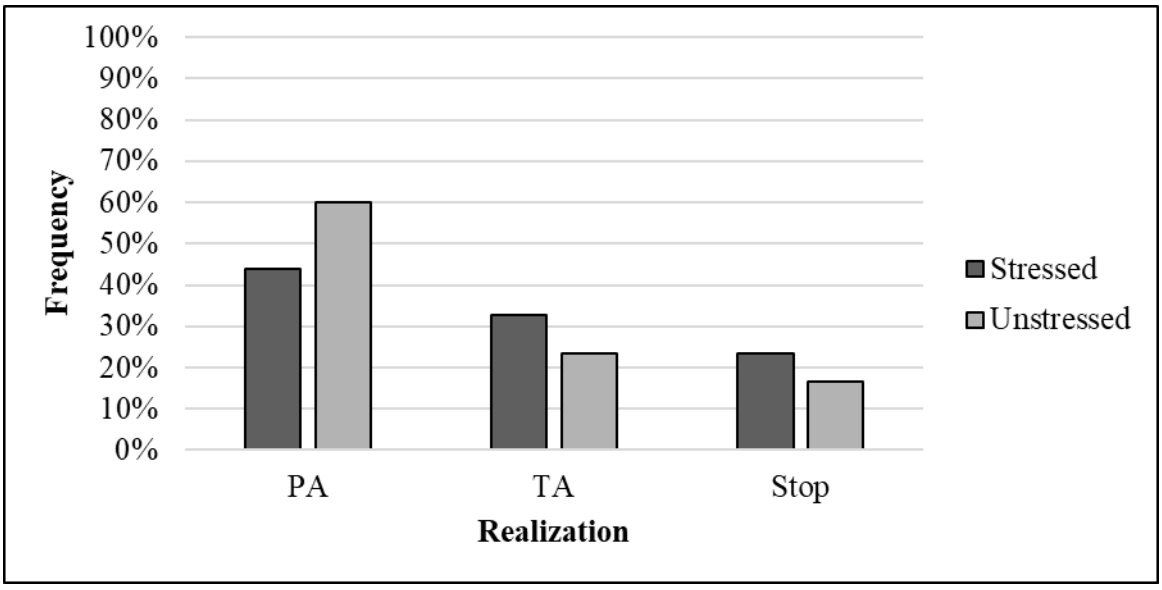
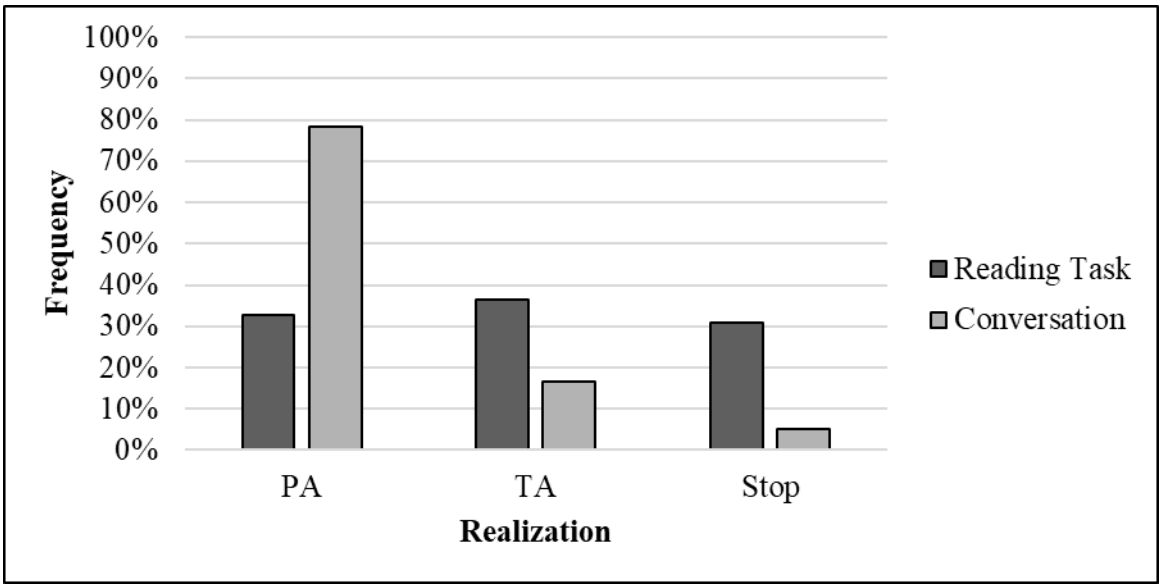


Figure 11 Task effects



References

Alvord, S. M., & Christiansen, D. E. (2012). Factors influencing the acquisition of Spanish voiced stop spirantization during an extended stay abroad. *Studies in Hispanic and Lusophone Linguistics*, *5*(2), 239-276.

Amengual, M. (2019). Type of early bilingualism and its effect on the acoustic realization of allophonic variants: Early sequential and simultaneous bilinguals. *International Journal of Bilingualism, 23(5),* 954-970.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). "Fitting Linear Mixed-Effects Models Using lme4." *Journal of Statistical Software*, 67(1), 1–48.

Blair, K., & Lease, S. (2021). An Examination of Social, Phonetic, and Lexical Variables on the Lenition of Intervocalic Voiced Stops by Spanish Heritage Speakers. *Languages*, *6*(2), 108.

Bonet, E. (2020). Spanish phonology at the syntax interface. In S. Colina & F. Martínez-Gil (Eds.) *The Routledge Handbook of Spanish Phonology.* (pp. 325-340). Routledge.

Broś, K., Żygis, M., Sikorski, A., & Wołłejko, J. (2021). Phonological contrasts and gradient effects in ongoing lenition in the Spanish of Gran Canaria. *Phonology*, 38(1), 1-40.

Cabrelli Amaro, J. (2017). The role of prosodic structure in the L2 acquisition of Spanish stop lenition. *Second Language Research*, *33*(2), 233-269.

Carrasco, P. (2008). *An acoustic study of voiced stop allophony in Costa Rican Spanish*. [Doctoral dissertation]. University of Illinois at Urbana-Champaign.

Carrasco, P., Hualde, J.I., & Simonet, M. (2012). Dialectal differences in Spanish voiced obstruent allophony: Costa Rican versus Iberian Spanish. *Phonetica (69)*, 149-179.

Colina, S. (2020). Spirantization in Spanish: The role of the underlying representation. *Linguistics*, *58*(1), 1-35.

de Lacy, P. (2004). Markedness conflation in optimality theory. *Phonology*, *21*(2), 145-199.

Díaz-Campos, M. (2004). Context of learning in the acquisition of Spanish second language phonology. *Studies in second language acquisition*, *26*(2), 249-273.

Eddington, D. (2011). What are the contextual phonetic variants of /β, ð, ɣ/ in colloquial Spanish? *Probus*, *23*(1), 1-19.

Face, T. L., & Menke, M. R. (2009). Acquisition of the Spanish voiced spirants by second language learners. In *Selected proceedings of the 11th Hispanic Linguistics Symposium* (pp. 39-52). Somerville, MA: Cascadilla Proceedings Project.

González-Bueno, M. (1995). Adquisición de los alófonos fricativos de las oclusivas sonoras españolas por aprendices de español como segunda lengua. *Estudios de lingüística aplicada*, (21).

Harper, D. (2014). *An analysis of perceptual factors in the evolution of Spanish approximants.* (Publication No. 3635837) [Doctoral dissertation, University of Colorado Boulder]. ProQuest Dissertations Publishing.

Hayes, B., Tesar, B. & Zuraw, K. (2003). OTSoft 2.5. [software package] http://www.linguistics.ucla.edu/people/hayes/otsoft/

Hualde, J. I. (2013). Intervocalic lenition and word-boundary effects: Evidence from Judeo-Spanish. *Diachronica*, *30*(2), 232-266.

Hualde, J. I. (2014). *Los sonidos del español.* Cambridge University Press.

Hualde, J. I., & Şaul, M. (2011). Istanbul Judeo-Spanish. *Journal of the International Phonetic Association*, *41*(1), 89-110.

Ito, J., & Mester, A. (2007). Prosodic adjunction in Japanese compounds. In M. Ochi & Y. Miyamoto (Eds.) *Formal approaches to Japanese linguistics 4* (pp. 97-111). MIT Press.

Ito, J., & Mester, A. (2009a). The extended prosodic word. In J. Grjzenhout & B. Kabak (Eds.) *Phonological domains: Universals and deviations.* (pp. 135-194). De Gruyter.

Ito, J., & Mester, A. (2009b). The onset of the prosodic word. In S. Parker (Ed.) *Phonological argumentation: Essays on evidence and motivation*. (pp. 227-260). Equinox.

Katz, J. (2016). Lenition, perception and neutralisation. *Phonology*, *33*(1), 43-85.

Katz, J., & Fricke, M. (2018). Auditory disruption improves word segmentation: A functional basis for lenition phenomena. *Glossa: a journal of general linguistics*, *3*(1), 38.

Katz, J., & Moore, M. W. (2021). Phonetic Effects in Child and Adult Word Segmentation. *Journal of Speech, Language, and Hearing Research*, *64*(3), 854-869.

Keating, P. A. (2006). Phonetic encoding of prosodic structure. In Harrington, J. & Tabain, M. (Eds.) *Speech production: Models, phonetic processes, and techniques*, 167-186.

Kingston, J. (2008). Lenition. In *3rd Conference on Laboratory Approaches to Spanish Phonology* (pp. 1-31). Cascadilla Proceedings Project.

Lozano, Claire J. 2021. Prosodically driven continuity lenition: A phonological account of spirantization in Colombian heritage Spanish. Ph.D. dissertation. University of California, Davis. Available at https://escholarship.org/uc/item/6jj5n8h5

Martínez-Gil, F. (2020). Spirantization and the phonology of Spanish voiced obstruents. In S. Colina & F. Martínez-Gil (Eds.) *The Routledge Handbook of Spanish Phonology.* (pp. 34-83). Routledge.

Migration Policy Institute. (2021). DataHub. Retrieved from https://www.migrationpolicy.org/programs/data-hub/charts/immigrants-countries-birth-over-time?width=1000&height=850&iframe=trueNespor & Vogel 1986

Nespor, M. &Vogel, I. (1986). *Prosodic Phonology*. Dordrecht,The Netherlands: Foris.

Quintana, A. (2006). Geografía lingüística del judeoespañol. *Bern: Peter Lang*.

Rao, R. (2014). On the status of the phoneme/b/in heritage speakers of Spanish. *Sintagma: revista de lingüística (26)*, 37-54.

Rao, R. (2015). Manifestations of /bdg/ in heritage speakers of Spanish. *Heritage Language Journal*, *12*(1), 48-74.

Rao, R. (2020). The phonological system of adult heritage speakers of Spanish in the United States. In S. Colina & F. Martínez-Gil (Eds.) *The Routledge Handbook of Spanish Phonology.* (pp. 439-451). Routledge.

Rao, R., & Ronquest, R. (2015). The heritage Spanish phonetic/phonological system: Looking back and moving forward. *Studies in Hispanic and Lusophone Linguistics*, *8*(2), 403-414.

Rogers, B., & Alvord, S. M. (2014). The gradience of spirantization. *Spanish in Context, 11*(3), 402-424.

Ronquest, R., & Rao, R. (2018). Heritage Spanish phonetics and phonology. In Potowski, K. (Ed.) *The Routledge handbook of Spanish as a heritage language*, 164-177.

Selkirk, E. O. (1978). On prosodic structure and its relation to syntactic structure. In Thorstein Fretheim (ed.), *Nordic Prosody II*. Trondheim: Tapir, 111–140.

Selkirk, E. O. (1984). *Phonology and Syntax. The Relation Between Sound and Structure*. Cambridge, MA: MIT Press.

Selkirk, E. O. (1986). On derived domains in sentence phonology. *Phonology*, *3*, 371-405.

Zampini, M. L. (1994). The role of native language transfer and task formality in the acquisition of Spanish spirantization. *Hispania*, 470-481.

Zampini, M. L. (1997). L2 Spanish spirantization, prosodic domains and interlanguage rules. *Language Acquisition and Language Disorders*, *16*, 209-234.

Zampini, M. L. (1998). L2 Spanish spirantization: A prosodic analysis and pedagogical implications. *Hispanic Linguistics*, *10*, 154-188.