Merger in Production and Perception? Bilingual Discrimination of Spanish [β] and [v]

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Mergers of allophones

- Mergers of expansion: access to a range of allophonic production, rather than production and perception leaning towards one end of continuum or other (Labov, 1994)

- Partial contrast: contrast within a pair (i.e., la[β]an and la[v]an) is lessened due to some process of leveling or neutralization (Trubetzkoy, 1939).

- Reduces perceptual discrimination for speakers within their native phonology, esp. regarding allophones (Hume and Johnson, 2003).

Allophones of /b/ in Spanish

- Merger of /b/ and /v/ in the 15th century (Penny, 2002)
  - [b] or [β] (voiced bilabial approximant/fricative), position-dependent

- Descriptive account of Spanish /b/
  - [b], [β], or [v], position-dependent (Romero, Guerreiro, & Alviárez, 2008; Carvalho, 2006; Rao, 2014; Trovato, 2018; Hualde et al., 2010:420-421)
  - Younger people producing [v]
    - Language contact with English

Hypotheses

- **RQ1:** How are mergers in production and mergers in perception related?
- **Operationalization:** Extract acoustic measurements from production data and include them as IV in a model where DV is discrimination accuracy
- **Hypothesis:** A merger of expansion in production in United States Spanish is correlated to a merger of perception, or a weakening of discrimination, of [β] and [v] (corresponding to orthographic <b> and <v>) in intervocalic position.

Hypotheses cont.

- **RQ2:** How does orthography (<v> versus <b>) affect discrimination accuracy?
- **Operationalization**: Stimuli used in production and perception tasks will include an equal number of words spelled with <v> as words spelled with <b>.
- **Hypothesis:** Because the merger of expansion is predicted to be most prevalent in words spelled with <v>, discrimination accuracy will be lower for words spelled with <v> than with <b>.

Stimuli

- Controlled phonological context - all instances of /β/ are **post-tonic** and in **intervocalic position**
- Male, native-Spanish speaker read token words twice, producing [β] in one iteration & [v] in another
- 9-step continuum, with base token generated from midpoint, steps of [β]-[v] spliced onto base
- Concatenated, 4 iterations of token word divided into pairs

<v>	<b>
cadáver	cabe
detective	caribe
comitiva	caníbal
lavan	graba
clave	casabe

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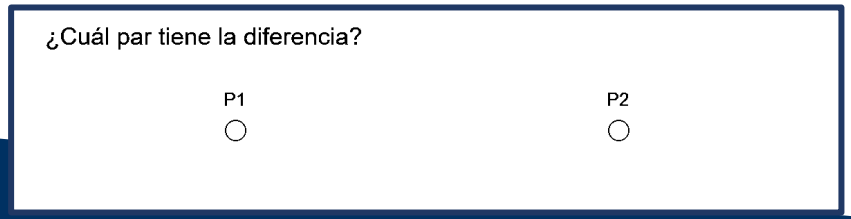
Participants & Procedure

- Two participant groups:
  - Early Spanish-English Bilinguals (simultaneous or childhood acquisition of English proficiency)
  - Late Spanish-English Bilinguals (acquisition of English at >18 years of age, born/raised in Spanish-dominant country)
- Experimental Procedure: 2 Tasks
  - **Reading Task**: participants read token words and fillers (to compare production with perception *prior to any priming from the perception task*)
  - **Discrimination Task**: Adapted roving 4I2AFC discrimination task (Gerrits & Schouten 2004)
    - 2 experiments of 120 trials each, plus practice trials



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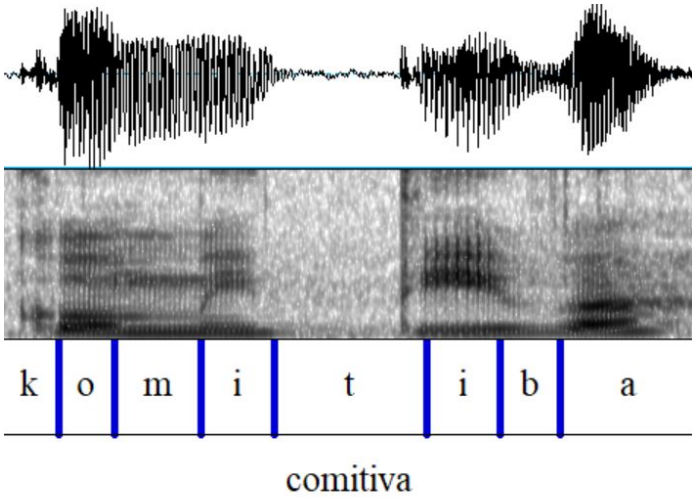
Acoustic Analysis of Production Data

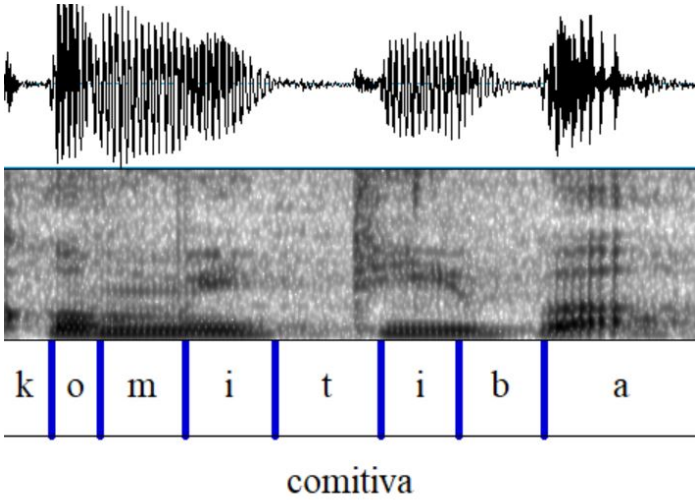
- TextGrids generated with Montreal Forced Aligner (McAuliffe et al. 2017) and Spanish dictionary (Morgan 2017); subsequently hand-corrected
- Acoustic measures of /b/ (Trovato, 2017; Mazzaro 2011)
  - Minimum intensity **[β] > [v]**
  - Duration **[v] > [β]**
  - Center of gravity **[β] > [v]**
- Z-Scores applied to intensity and cog measurements
- Duration of /b/ relative to duration of VbV segment
  - According to null hypothesis, duration of VbV segment for every word should be equal, regardless of orthography

Sample Production Data

- Lang. Profile: Late
- More [β]-like?
- Minimum Intensity: 56.21 dB
- Duration: 49.188 ms
- Rel. duration: 0.25
- Center of gravity: 3002.28 Hz



- Lang. Profile: Early
- More [v]-like?
- Minimum intensity: 62.58 dB
- Duration: 60.09 ms
- Rel. duration: 0.24
- Center of gravity: 2675.28 Hz



Statistical Analysis

- **Mixed-effects logistic regression** in R (R Core Team 2018) *failed to converge*

- **Fixed-effects logistic regression:**
  - *1. orthography + scale(intensity) * language profile * interval pair*
  - *2. orthography + duration * language profile * interval pair*
  - *3. orthography + scale(cog)* language profile * interval pair*

Results – Intensity Model

Coefficients		Estimate	Std. Error	z value	Pr (>|z|)	Accuracy
(Intercept)		**0.427031**	**0.152552**	**2.799**	**0.00512**	60.52%
Orthography	**<v>**	**-0.192114**	**0.079987**	**-2.402**	**0.01631**	55.85%
Interval pair	2-5	0.058261	0.207069	0.281	0.77844	
	3-6	0.062047	0.207046	0.300	0.76442	
	4-7	0.103863	0.208928	0.497	0.61910	
	5-8	-0.344712	0.205134	-1.680	0.09287	
	6-9	-0.227986	0.205252	-1.111	0.26667	
Language Profile Late		**-0.420270**	**0.196747**	**-2.136**	**0.03267**	50.17%
Intensity (z-score)		**0.296622**	**0.148535**	**1.997**	**0.04583**	53.26% (1 SD below mean) 67.34% (1 SD above mean)

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<v> ↓ **Late Bilingual** ↓ **Higher Intensity** ↑

(Prediction **[β] > [v]**)

Figure 1: Response by orthography

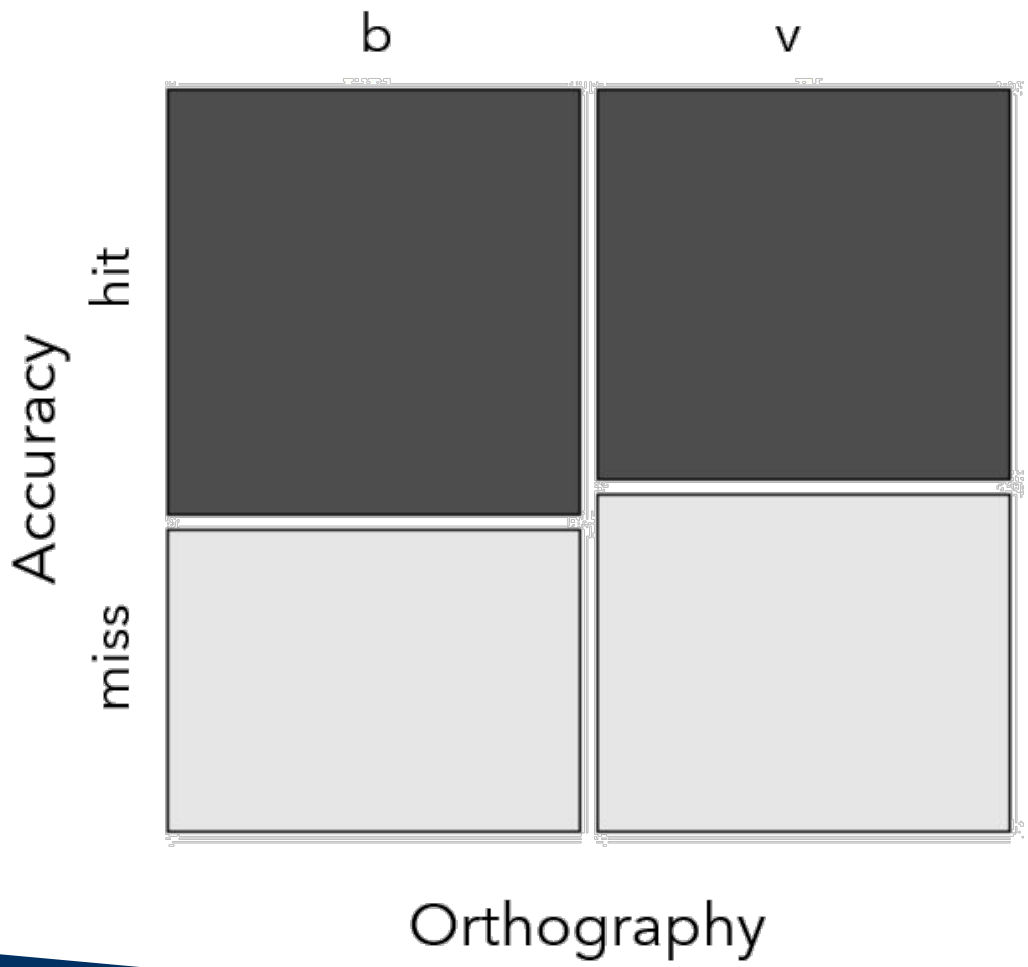

Figure 2: Interval Pair*Language Profile

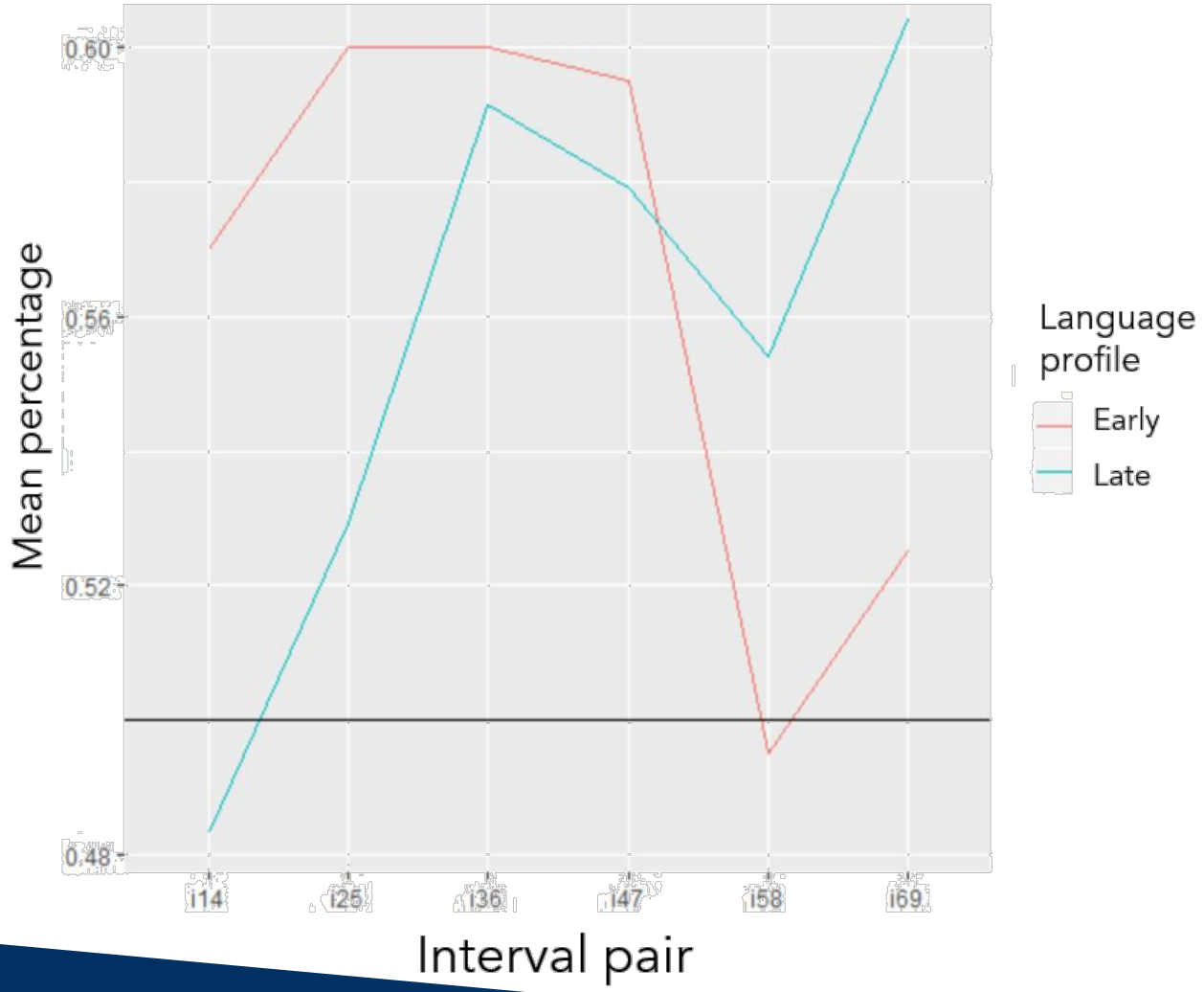

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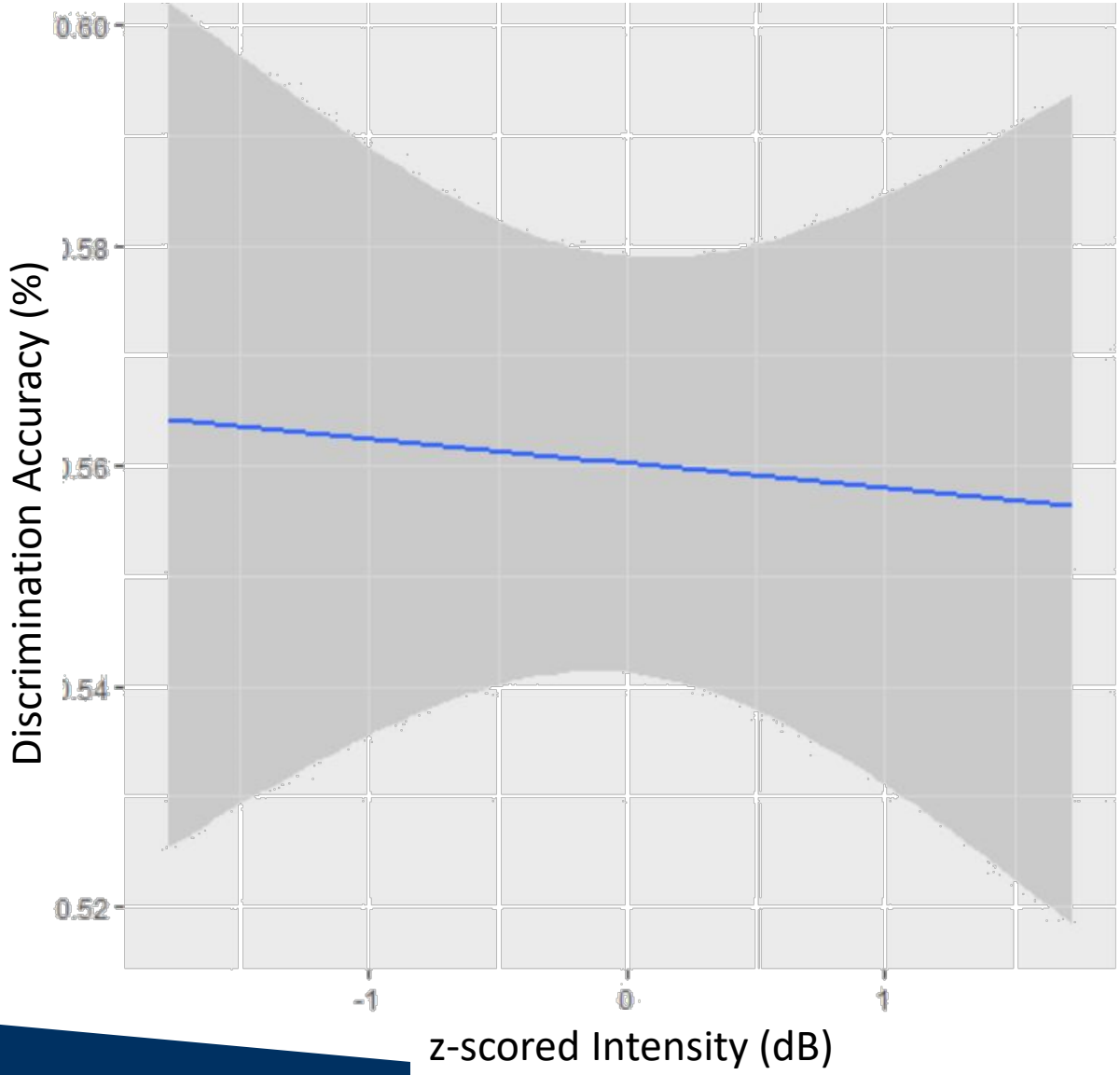
Figure 3: Response (% Accuracy) by Intensity (dB)



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Results – COG Model

Coefficients		Estimate	Std. Error	z value	Pr (>|z|)	Accuracy
(Intercept)		**0.33895**	**0.15308**	**2.214**	**0.02681**	58.39%
Orthography	**<v>**	**-0.19986**	**0.07933**	**-2.519**	**0.01176**	53.47%
Interval pair	2-5	0.18192	0.21021	0.865	0.38680	
	3-6	0.21755	0.21175	1.027	0.30424	
	4-7	0.09923	0.20942	0.474	0.63561	
	5-8	-0.22449	0.20810	-1.079	0.28069	
	6-9	-0.04392	0.21106	-0.208	0.83517	
Language Profile	Late	-0.30284	0.19678	-1.539	0.12381	
Center of Gravity (z-score)		-0.27639	0.22228	-1.243	0.21370	

Results – COG Model

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(Intercept)	**0.33895**	**0.15308**	**2.214**	**0.02681**	58.39%
Orthography <v>	**-0.19986**	**0.07933**	**-2.519**	**0.01176**	53.47%

<v> ↓ **Late Bilingual** — **COG** —

(Prediction **[β] > [v]**)

Results – Duration Model

Coefficients		Estimate	Std. Error	z value	Pr (>|z|)	Accuracy
(Intercept)		**1.22324**	**0.58533**	**2.090**	**0.0366**	77.26%
Orthography	**<v>**	**-0.20206**	**0.07935**	**-2.546**	**0.0109**	73.52%
Interval pair	2-5	-1.41125	0.82685	-1.484	0.1378	
	3-6	-1.37236	0.82644	-1.661	0.0968	
	4-7	-0.75088	0.82287	-0.913	0.3615	
	5-8	-1.09370	0.81577	-1.938	0.28069	
	6-9	-0.04392	0.21106	-0.208	0.0527	
Language Profile	Late	-0.44248	0.80376	-0.551	0.5820	
Relative Duration		-4.44367	2.99434	-1.484	0.1378	

Results – Duration Model

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(Intercept)	**1.22324**	**0.58533**	**2.090**	**0.0366**	77.26%
Orthography <v>	**-0.20206**	**0.07935**	**-2.546**	**0.0109**	73.52%

<v> ↓ **Late Bilingual** — **Duration** —

(Prediction **[v] > [β]**)

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Discussion

RQ1:

- Language profile (early or late bilingual) has a significant effect on discrimination accuracy. Listeners (early bilinguals) can better perceive phones in their native inventory (Hume & Johnson, 2003)
- Intensity of /b/ segment in participant production is inversely correlated with discrimination accuracy. More [β]-like productions have greater perceptual accuracy → Merger of Expansion Theory (Hume & Johnson, 2003; Labov, 1994; Trubetzkoy, 1939)

RQ2:

- Orthography is a significant predictor for perceptual accuracy, where <v> corresponds to less perceptual accuracy than <b>.

Additional results:

- From this data, intensity (dB) is the only metric that supports the prediction of a relationship between production and perception. COG and duration were not shown to be significant predictors of perceptual accuracy.

Future Considerations

- Statistical model
  - Collect more data so that mixed model can converge (accounts for speaker differences)
- Acoustic measures
  - Measurement of velocity of air flow in order to place productions on a continuum between fricatives and approximates (i.e. relative turbulence of air flow)
- Matched guise test
  - What attitudes do speakers have towards a gradient production of intervocalic /b/? Are different productions on the allophonic continuum more salient than others?
- Other production/perception studies
  - Do our predictions hold?

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