

Voice onset time (VOT) of L3 Spanish /ptk/ by multilingual heritage speakers of Ukrainian and Polish

MARGARYTA BONDARENKO
University of Wisconsin -
Madison

BRIANNA BUTERA
University of Memphis

RAJIV RAO
University of Wisconsin -
Madison

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ABSTRACT

EN This study provides an acoustic analysis of voice onset time (VOT) of voiceless stops /ptk/ in Spanish, produced by heritage speakers (HSs) of Ukrainian and of Polish who are English-dominant and beginner or intermediate learners of Spanish as a third language (L3). Given that both Ukrainian and Polish, like Spanish and unlike English, are characterized by short-lag VOT, data were collected from six Ukrainian HSs and 11 Polish HSs in their heritage language (HL), in English, and in Spanish to compare potential effects of the HL on L3 VOT production. VOT was analyzed in three task types. The goals were: 1) to determine whether VOT values produced in Spanish by Ukrainian and Polish HSs are more reflective of VOTs in the HL or in English, and 2) to determine the effect of task type on VOT. Data show that Ukrainian and Polish HSs' VOTs in Spanish are shorter than those of L2 Spanish learners whose L1 is English, indicating a HL rather than dominant language influence on L3 VOT. Results suggest that the most crucial factors in L3 phonological acquisition are: 1) structural similarity between HL and L3, and 2) L3 proficiency (not language dominance). VOT was also affected by task type: like L1 Spanish speakers, VOT of Ukrainian HSs increases as task formality increases. This paper fills research gaps in HL and L3 phonetics/phonology as to the effects of a HL on the acquisition of subsequent sound systems in adulthood.

Key words: L3 PHONOLOGY, HERITAGE LANGUAGE PHONOLOGY, CROSS-LINGUISTIC INFLUENCE, VOICE ONSET TIME (VOT), L3 LEARNING

ES Este estudio ofrece un análisis acústico del tiempo de emisión de voz (VOT, *voice onset time*) de las oclusivas sordas /ptk/ en español, producidas por hablantes de herencia (AH) de ucraniano y polaco cuya lengua dominante es el inglés y que aprenden español como L3 a nivel inicial o intermedio. Dado que tanto el ucraniano como el polaco, al igual que el español y a diferencia del inglés, se caracterizan por un VOT de lazo corto, se recopiló datos de seis AH ucranianos y 11 AH polacos en su lengua de herencia (LH), en inglés y en español. Los objetivos eran determinar: 1) si los VOT producidos en español por estos AH reflejan más la LH o el inglés, y 2) el efecto del tipo de tarea. Los datos muestran que los VOT en español de los AH de ucraniano y de polaco son más cortos que los de estudiantes de español L2 cuya L1 es el inglés, lo que indica una influencia de la LH –no de la lengua de dominancia– en la producción de VOT. Los resultados sugieren que los factores más cruciales en la adquisición fonológica de la L3 son: 1) similitud estructural entre la LH y la L3, y 2) competencia lingüística en la L3. El VOT de los AH ucranianos aumenta conforme aumenta la formalidad de la tarea. Este trabajo llena las lagunas de la investigación en fonética/fonología de LH y L3 en cuanto a los efectos de una LH en la adquisición de sistemas sonoros posteriores en la edad adulta.

Palabras clave: FONOLOGÍA DE L3, FONOLOGÍA DE LA LENGUA DE HERENCIA, INFLUENCIA INTERLINGÜÍSTICA, VOT, APRENDIZAJE DE L3

IT Questo studio fornisce un'analisi acustica del tempo di attacco della sonorità (VOT, *voice onset time*) delle oclusive sorde /ptk/ in spagnolo da parte di apprendenti di livello base o intermedio di spagnolo come L3 che sono i parlanti di ucraino e polacco come lingue ereditarie (LE) ma con l'inglese come lingua dominante (LD). I dati sono basati su sei parlanti di ucraino LE e undici di polacco LE. Il VOT è analizzato in tre lingue—LE, inglese e spagnolo—con l'obiettivo di determinare 1) se i valori di VOT prodotti in spagnolo dagli ucraini e dai polacchi riflettono di più la LE o la LD, 2) gli effetti del tipo di esercizio sul VOT. I dati dimostrano che i VOT in spagnolo dei parlanti di ucraino e polacco come LE sono più brevi di quelli degli apprendenti di spagnolo L2 con inglese L1. Ciò indica che la LE influenza la produzione del VOT rispetto alla LD. I risultati suggeriscono che nell'acquisizione fonologica di una L3 sono cruciali: 1) la similarità strutturale tra LE e L3, e 2) la competenza nella L3. Inoltre, come per i parlanti di spagnolo L1, il VOT dei parlanti di ucraino aumenta con l'aumentare della formalità dell'esercizio. Questo articolo colma un vuoto nello studio della LE e della fonetica/fonologia della L3 relativo agli effetti di una LE sull'acquisizione di un successivo sistema di suoni nell'età adulta.

Parole chiave: FONOLOGIA DELLA L3, FONOLOGIA DELLA LINGUA EREDITARIA, INFLUENZA CROSS-LINGUISTICA, VOT, APPRENDIMENTO DELLA L3

✉ **Rajiv Rao**, University of Wisconsin-Madison
rgrao@wisc.edu

1. Introduction

Over roughly the last decade, the field of third language (L3) phonetics and phonology has gained significant traction. Scholarship during this period has aimed to determine whether it is structural similarity (Rothman, 2015) or language dominance (Hammarberg & Hammarberg, 2005; Llama & López-Morelos, 2016; Wrembel, 2010, 2014, 2015) that is most influential in L3 phonetics and phonology.¹ Furthermore, since the turn of the century, but mostly within the last decade, the study of heritage language (HL) phonetics and phonology has also gained wider recognition. Studies on Spanish and Slavic heritage speakers (HSs) (e.g., Łyskawa et al., 2016; Nagy & Kochetov, 2013; Rao & Ronquest, 2015; Ronquest & Rao, 2018) show that HSs are a heterogeneous group of speakers who do not always perform like native monolingual speakers or late bilinguals, but have more native-like productions than second language (L2) learners, with accuracy often correlating with frequency of HL use. The goal of this investigation is to combine these two areas of multilingual phonetics and phonology in order to shed light on speakers of lesser-studied HLs in the United States by examining their experiences learning an L3. The particular focus is on the speech of Ukrainian and Polish HSs and their acquisition of Spanish /ptk/, a consonant series whose features are similar in Spanish and Slavic languages, both of which differ from English. The Ukrainian and Polish HS population in the United States is of a notable size; the 2019 American Community Survey (ACS) stated that there are 8,969,530 people of Polish ancestry in the United States, out of which, 510,430 speak Polish, and the American of Ukrainian descent population reaches 1,009,874, of which 321,876 speak Ukrainian. While these numbers are significant, Ukrainian and Polish are not commonly offered in schools and higher education institutions. Therefore, when choosing to learn an L3, these HSs often pick Spanish, the most popular world language option in the United States, motivated by the increase in career opportunities that knowledge of Spanish provides (Goldberg et al., 2015).

Focusing specifically on two unique groups of speakers, Ukrainian HSs and Polish HSs, allows us to address several questions in one study. First, it helps us understand how language acquisition during childhood influences subsequent language learning in adulthood, allowing us to identify the potential influence of an HL on the acquisition of L3 phonetics and phonology. Second, by selecting HSs whose HL realization of voiceless stops differs from that of the dominant language (DL), but coincides with that of the L3, this study allows us to present evidence as to which language exhibits greater influence on the L3. These aspects, in turn, help inform us whether it is language dominance and/or structural similarity that is/are the most influential during the acquisition of an L3 sound system, which can then inform theoretical frameworks addressing the acquisition of L3 sound systems (see Kopečková et al., 2016). Overall, the results and conclusions from this study on Ukrainian HSs and Polish HSs contribute to a recently growing field of research on HL and L3 phonetics and phonology.

2. Previous research on VOT

In this study, we investigate VOT of Spanish voiceless stops /ptk/. VOT is the interval between the stop burst (i.e., release of contact between articulatory organs) and the onset of vocal fold vibration in a following sound, and is used to differentiate between unaspirated voiceless stops and aspirated stops and to convey contrast between voiced and voiceless segments. Previous research on L2 acquisition has documented that Spanish /ptk/ cause difficulties for first language (L1) English learners of L2 Spanish because they are produced differently in English (see Zampini, 2019 for a summary). Spanish is a language with short-lag VOTs, where /ptk/ are produced with VOT values that are around 30 milliseconds² (ms) or shorter (i.e., unaspirated).³ Ukrainian and Polish, both Slavic languages, also exhibit short-lag VOTs, although VOTs for the velar segment /k/ in Polish can exceed 50 ms. The acoustic analysis of VOT for Polish speakers in Keating et al. (1981) shows mean VOT values below 30 ms for /p/ and /t/. In their analysis, mean VOT values for /k/ slightly exceeded 50 ms, which was unexpected, but potentially influenced by the effect of place of articulation on VOT (Keating et

¹ In this paper, structural similarity refers to the phonetic properties (i.e., voice onset time (VOT)) of the languages investigated (i.e., Ukrainian, Polish, Spanish, and English).

² Cho and Ladefoged (1999) showed that velars have the highest VOT values, which can exceed 30 ms in languages with short-lag VOT.

³ To our knowledge, there are no available data on concrete estimated VOT values for Ukrainian /ptk/. Therefore, we will rely on measurements provided by Ringen and Kulikov (2010), who worked with a group of Russian monolinguals. Since Ukrainian, Polish and Russian all belong to the Slavic language family, which is known for short-lag VOTs, it is reasonable to assume that the VOT values of /ptk/ in Ukrainian would be relatively comparable to those of Polish and Russian.

al., 1980; Lisker & Abramson, 1964). Waniek-Klimczak (2011) found similar VOT values for both /p/ and /k/, lower than 30 ms and slightly above 50 ms, respectively, for native monolingual speakers of Polish. English, on the other hand, exhibits long-lag VOTs, where voiceless stops, specifically those that appear in word-initial and stressed positions, are often produced with VOTs that are longer than 30 ms (i.e., aspirated). In fact, English stops usually have VOTs that are greater than 50 ms (Lisker & Abramson, 1964). In English, short-lag VOT values are reserved for the production of the voiced stops /bdg/, which in Spanish, Ukrainian, and Polish are realized with pre-voicing (i.e., voicing begins before the stop burst) and are described using negative VOT values. This contrast highlights the importance of VOT, which has both phonemic and allophonic consequences in the four languages in question (Cho & Ladefoged, 1999; Lisker & Abramson, 1964; Ringen & Kulikov, 2010; Rosner et al., 2010). Figure 1 presents a waveform and spectrogram image taken from *Praat* (Boersma & Weenink, 2016) highlighting a Spanish production of word-initial [p] in the word *papa* ('potato'), as produced by an L1 speaker of Spanish. VOT in this figure is indicated between the two vertical dotted lines and the time marker label at the bottom. The left vertical dotted line aligns with the stop burst (i.e., beginning of VOT measurement), where the waveform goes from an inactive to an active state, and the right one signals the first periodic cycle of the following [a] (i.e., end of VOT measurement). The VOT measurement of [p] in this figure is 6.8ms, indicative of a short-lag VOT classification, characteristic of Spanish, Ukrainian, and Polish.

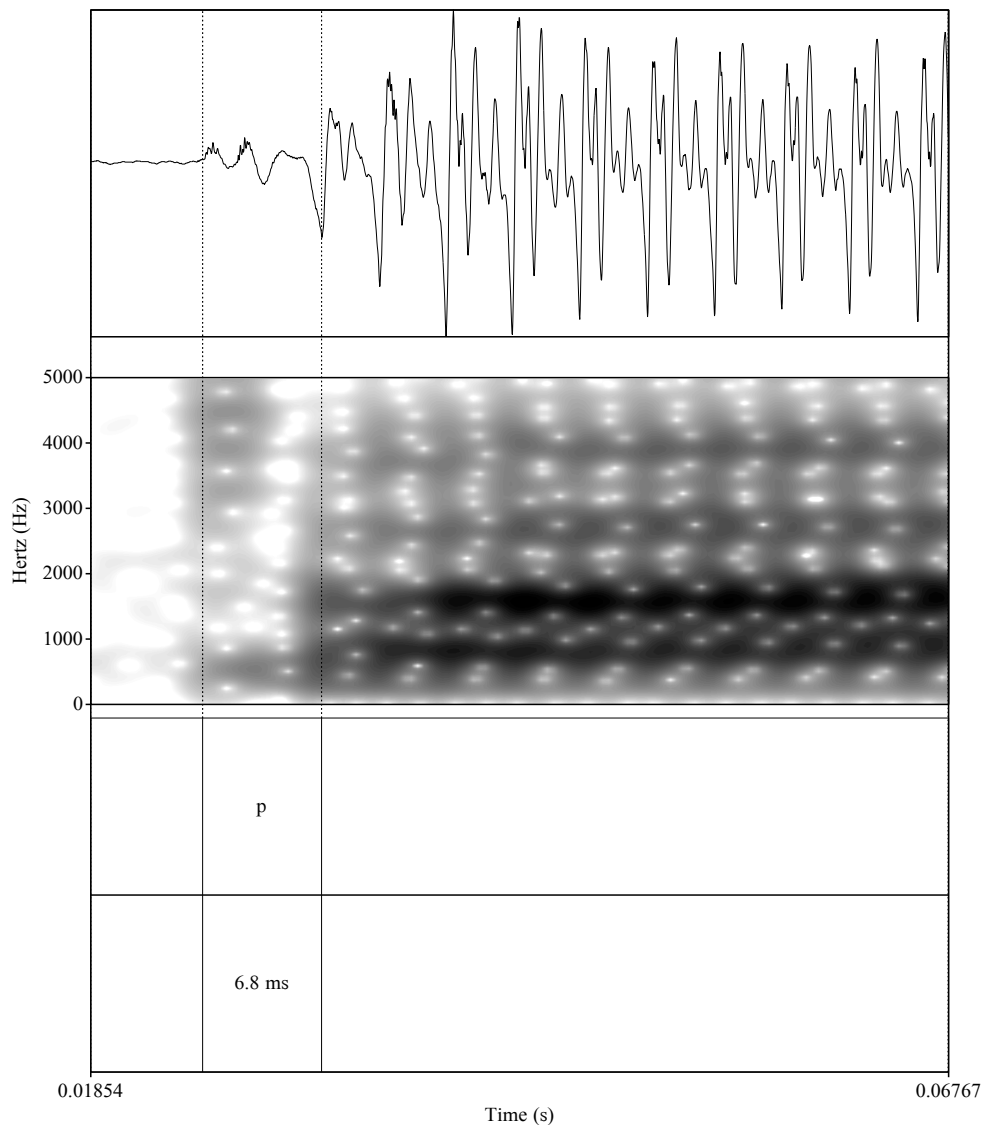


Figure 1. Spanish production of word-initial [p] in *papa* by an L1 Spanish speaker

3. Heritage and L3 VOT

Previous studies on HSs of Spanish have shown that they typically have more native-like productions than L2 learners, with accuracy strongly correlating with frequency of HL use. Au et al. (2008) and Knightly et al. (2003) examined the speech of HSs with different HL experiences and exposure rates, showing that HSs' productions of /ptk/ are more target-like than those of typical late L2 learners, with active HL users performing in a more native-like manner than HL overhearers. Kim (2011) showed that HSs' perception of Spanish /ptk/ also differs significantly from that of native English speakers who are learning Spanish, while showing no significant difference from native Spanish speakers. The studies by Hrycyna (2011) and Nagy and Kochetov (2013), which examined VOTs of Ukrainian and Russian HSs in an English-speaking environment, revealed that production also largely depends on generational shifts, with each generation displaying their own language norms.

When it comes to L3 learners, some studies suggest that L2 status is more influential than the L1 in the production of L3 segments. Llama et al. (2008, 2010) tested VOT production of Canadian L1 English L2 French and L1 French L2 English speakers who were intermediate learners of L3 Spanish and showed that L2 status, not structural similarity, was more significant in the production of L3 stops. Tremblay's (2007) work on L1 English L2 French L3 Japanese learners also examined voiceless stops, and like the previous two studies, found L2 influence to be stronger. Wrembel's (2011, 2014) studies on voiceless stops in the speech of L1 Polish L2 English L3 French and L1 Polish L2 English L3 German speakers, however, revealed contrasting VOT values in all three languages, which the author attributed to a combined influence of both the L1 and L2 on the L3.

Hammarberg and Hammarberg (2005) claimed that during the initial stages of L3 phonological acquisition, the L2 more strongly influences L3 phonology; this claim is supported by evidence from a well-known longitudinal study of an L1 British English L2 German L3 Swedish learner. As the speaker became more familiar with the Swedish sound system, reliance on German gradually reduced. Wrembel (2009) investigated L1 Polish L2 German L3 English speakers' perceived foreign accent in English and corroborated these findings, revealing that the perception of language background depended greatly on the state of L3 proficiency. Participants at higher levels of the L3 were correctly identified as native Polish speakers, while elementary and beginner groups tended to be placed in the L1 German category.

Llama and López-Morelos (2016) studied VOT production in adolescent trilingual HSs (i.e., heritage/L1 Spanish, L1 dominant in English and L3 French). Since Spanish and French are both characterized by short-lag VOT, the authors hypothesized that speakers would have a phonological advantage in the L3 with respect to VOT of /ptk/; however, their findings showed longer VOTs in the L3 in comparison to the monolingual French norm. The authors suggest two possible rationales to explain this divergence, given that the data from their HSs showed that they can and do produce short-lag VOTs in their HL. HSs were either transferring their VOT values from the DL, English, or were imitating the values of their classmates, who served as their main source of French input in the language classroom.

Studies have shown that speech style is another important variable to consider when working with language learners. While some have argued that task formality increases accuracy in L2 learners (Major, 1986), others have presented evidence showing that casual speech results in increased learner accuracy, with Rao (2015) and Zampini (1994) reporting more accurate productions of voiced intervocalic stops in L1 English L2 Spanish learners and Spanish HSs, respectively, in conversational tasks than in reading elicitations. Additionally, by examining vowel production in Spanish HSs, Ronquest (2016) showed vowel space expansion and lengthening in clear speech conditions, such as reading, and centralization of vowels in conversational speech. Finally, Asherov et al.'s (2016) study on Russian HSs demonstrated the value of implementing tasks with nonce words over real words, arguing that the former serve as a useful way of testing whether a phonological process is productive rather than lexicalized.

4. Motivations and research questions

As motivated by the literature reviewed to this point, the goal of this study is to investigate the phonological systems of two groups of Slavic HL speakers, Ukrainian HSs and Polish HSs, both of whom grew up in an English-dominant environment and are acquiring the Spanish sound system as L3 learners. This study sheds light on whether structural similarity between languages or language dominance exhibits the most influence on L3 acquisition. The specific research questions guiding this study are the following:

- 1) Is VOT production of Spanish /ptk/ by Ukrainian HSs and Polish HSs influenced by knowledge of their HL or DL sound system?
- 2) What is the effect of task type on VOT of Spanish /ptk/ for Ukrainian HSs and Polish HSs?

Given the structural similarity between the HL of the participants and their L3, Spanish, we hypothesized that this factor will be most influential in L3 production. Since the HLs and the L3 are all characterized by short-lag VOT, we predict that HSs of Ukrainian and Polish will produce shorter VOT values than L1 English L2 Spanish speakers, thus more closely reflecting the short-lag L1 VOT values of L1 Spanish L2 English speakers. Although Ukrainian HSs and Polish HSs are treated as two independent participant groups for this study, we hypothesize that they will both perform similarly with respect to VOT production and task type. Regarding the second research question, previous research suggests that more casual speech, such as that elicited by a narrative task, will yield more accurate VOT production when compared to the more formal speech style of sentence and nonce word reading tasks.

5. Methodology

5.1. Background measures

As emphasized by Cabrelli Amaro (2013), gathering sufficient background information on participants is the very first step to effective L3 research. For this purpose, two questionnaires were utilized. The first of these was a language history questionnaire, adapted from Oh and Au (2005), requesting basic information about place of birth (POB), POB of parents and grandparents, number of years residing in the United States (and age of arrival, if applicable) and outside of the country, places of residence, and current language use and self-perceived dominance. The speakers were also asked to self-assess their speaking, understanding, reading, and writing performance in Spanish on a 0-6 Likert scale.

The HS groups were also administered the Bilingual Language Profile (BLP) (Birdsong et al., 2012), which was developed to assess language dominance through self-reports.⁴ It inquires about a variety of factors, such as age of acquisition and exposure, years of schooling, frequency and function of use, linguistic environment, language attitudes, and proficiency and processing ability. The final score ranges from -218 to +218, with a result closer to zero demonstrating that an individual is a balanced bilingual and more positive or more negative scores reflecting dominance in the language for which an individual accrues more points. Implementing this tool allowed for a direct comparison of dominance between participants in the interpretation of results.

5.2. Participants

For the current study, data were collected from 27 total participants. The two experimental groups included six Ukrainian HSs and 11 Polish HSs. Both HS groups are dominant in English and are L3 learners of Spanish. Cabrelli Amaro (2013) also argues for the inclusion of control groups, strongly urging that they not solely consist of monolingual native speakers, who represent a standard that is often out of reach for language learners. Therefore, the data set includes two bilingual control groups comprised of five participants each: L1 English L2 Spanish and L1 Spanish L2 English.

5.2.1. Ukrainian HSs

Six Ukrainian HSs living in Chicagoland, with a mean age of 29.7, were recruited for this study (see Table 1 for key participant background information). They reported using their HL with family members and some friends, and English in all other circumstances. Their mean BLP score was 34.5, indicating English dominance. The speakers began learning Spanish between ages five and 14, with a mean age of 10.7. They reported using it between 0-10% per week, with most activity occurring in a classroom setting. When asked to provide a self-rated proficiency (SRP) in Spanish, their reading score was the highest, averaging 4.75, followed by writing, at 4.5. Comprehension received an average score of 4.25 and speaking an average of 3.7. It is noteworthy to comment on speaker U6, since their biographical data differs from that of the other Ukrainian HSs in that Spanish is their L2. U6 was born in Argentina, learned Ukrainian as a HL at home, but had Spanish

⁴ Because control group speakers are not the study's main focus and were used primarily for baseline comparison, they did not complete a BLP. L1 English L2 Spanish participants did not begin learning Spanish until at least age 12 and are thus assumed to be English dominant. L1 Spanish L2 English participants arrived in the United States in early adulthood. Spanish was their primary language prior to moving to the United States (for more, see Rao, 2019).

as the dominant language of the environment; however, upon arriving to the United States at eight-years-old, U6 began learning English in an English-dominant environment to the point that at 64 years old, the L3 was currently the dominant language. While these circumstances are distinct, U6 was still considered a Ukrainian HS that learned a HL at home.

Table 1
Ukrainian HSs' biodata

Speaker	Age	Place of birth (POB)	Language acquired (LA) first	LA second (age)	Reported L1	Reported L2	(BLP) score	Age of learning (AOL) Spanish (L3)	Spanish self-rated proficiency (SRP)
U1	20	IL	Ukrainian (since birth [SB])	English (3)	Ukrainian	English	33.4 (English dominant [ED])	12	3, 4, 5, 5*
U2	33	IL	Ukrainian (SB)	English (4)	English	Ukrainian	86.8 (ED)	10	4.5, 4.5, 4.5, 4.5
U3	21	Ukraine	Ukrainian (SB)	English (9)	Ukrainian	English	-103.8 (Ukrainian dominant)	14	2.5, 3, 4, 2.5
U4	19	IL	Ukrainian (SB)	English (3)	Ukrainian	English	30.7 (ED)	12	3, 4, 4, 5
U5	21	Ukraine	Ukrainian (SB)	English (5)	English	Ukrainian	82.3 (ED)	11	4, 4, 5, 4
U6	64	Argentina	Ukrainian (SB)	Spanish (5)	Ukrainian	Spanish	77.37 (ED)	5	5, 6, 6, 6

*scores indicate self-ratings in: speaking, listening, reading, writing

5.2.2. Polish HSs

The Polish HS group consisted of 11 speakers, with a mean age of 20.2, also residing in Chicagoland (see Table 2 for key participant background information). They reported using Polish with family and certain friends. Their mean BLP score was 51.8, meaning this group was more English dominant as a whole than the Ukrainian HSs.

The participants began learning Spanish between the ages of 10 and 15, with a mean age of 12.8 (later than the Ukrainian HSs), and estimated using it 0-20% of the time during an average week. Those who utilized Spanish reported using it in class, and occasionally with friends outside of class. In their SRP for Spanish, comprehension received a mean score of 3.8, reading 3.4, writing 3.4, and speaking 2.8. Overall, these scores were lower than those of the Ukrainian HSs.

Table 2
Polish HSs' biodata

Speaker	Age	POB	LA first	LA second	Reported L1	Reported L2	BLP score	AOL Spanish	Spanish SRP
P1	18	IL	Polish (SB)	English (3)	Polish	English	52.6 (ED)	14	3, 4, 5, 3*
P2	21	WI	Polish and English (SB)		English	Polish	62.8 (ED)	13	3.5, 3.5, 3.5, 4
P3	22	Poland	Polish (SB)	English (9)	Polish	English	59.6 (ED)	15	1, 2, 1, 1
P4	20	IL	Polish and English (SB)		Polish	English	100 (ED)	14	0, 0, 2, 0
P5	19	IL	Polish (SB)	English (4)	Polish, Russian	English	79.2 (ED)	12	3, 4.5, 6, 4.5
P6	21	IL	Polish (SB)	English (3)	Polish	English	15.1 (ED)	12	3, 4, 4, 4
P7	19	IL	Polish (SB)	English (3)	Polish	English	44.9 (ED)	12	4, 5, 5, 4
P8	21	IL	Polish and English (SB)		English	Polish	30.4 (ED)	12	5, 6, 5, 5
P9	21	IL	Polish and English (SB)		English, Polish		42.5 (ED)	10	4, 4, 5, 3
P10	18	IL	Polish (SB)	English (5)	Polish	English	-25.2 (Polish dominant)	15	2, 4, 5, 5.6
P11	22	MN	Polish and English (SB)		English	Polish	107.8 (ED)	12	3, 5, 4, 3

*scores indicate self-ratings in: speaking, listening, reading, writing

As indicated in Tables 1 and 2, some of the HSs, especially in the Polish group, reported learning their HL and English simultaneously since birth or at a very young age, rendering potential influence of order of language acquisition irrelevant. Therefore, the current study places its focus primarily on HL/DL influence on L3 phonology rather than order of acquisition.

The two background surveys administered to the HS participants (i.e., the language history questionnaire and the BLP) were primarily used to understand each participant's background. The BLP scores of both the Polish HSs and the Ukrainian HSs were statistically equivalent, indicating that their level of language dominance in their HL, Polish and Ukrainian, respectively, was the same.⁵

⁵ Further examination of the BLP scores within the two HS groups rigorously explored whether they are indeed equivalently dominant in their HL. A standard two-sample t-test (which assumes equal variance across two samples) was run and yielded the following results: the t-stat is -0.66 with 15 degrees of freedom, and the corresponding *p*-value is > 0.05. These results indicate that the BLP scores between the two groups are statistically the same. In addition, a Welch two-sample t-test (which assumes unequal variance across two samples) was run where the *p*-value is > 0.05, further supporting equivalence in language dominance for both Polish and Ukrainian HSs. Another attempt to distinguish potential differences between the two HS groups was to determine an overall language ability score for each speaker; however, both production and comprehension ability scores are still not significant, despite the fact that the Ukrainian HS group did score higher than the Polish HS group.

5.2.3. Control groups

The L1 English L2 Spanish speakers (mean age = 19.4) were currently enrolled in an undergraduate program at a large university in the Midwest region of the United States at the time of this study (see Table 3 for key participant background information). The mean age of learning Spanish for these speakers is 12.6 years old. In the SRP, comprehension received a mean of 4.4, reading 3.9, writing 3.7, and speaking 3.6. These numbers overall more closely resembled those of the Polish HSs than those of the Ukrainian HSs. Finally, all five L2 Spanish participants reported using Spanish between 10-20% of the time per week, only during class time.

Table 3
L1 English L2 Spanish participants' biodata

Speaker	Age	POB	AOL	
			Spanish	Spanish SRP
E1	18	WI	12	3.5, 5, 4, 4*
E2	21	IL	13	3, 3, 3, 3
E3	19	WI	12	3, 4, 3, 3
E4	19	WI	13	4.5, 5, 4.5, 4.5
E5	20	WI	13	4, 5, 5, 3

*scores indicate self-ratings in: speaking, listening, reading, writing

The L1 Spanish L2 English participants (mean age = 32.6) were graduate students in the Spanish Department of a large university in the Midwest region of the United States at the time of this study (see Table 4 for key participant background information). They began learning English between 3-21 years of age, with a mean of 11. When asked to assess their L2 proficiency in English, the average reported scores were as follows: reading – 5.6, writing – 4.6, comprehension – 5, and speaking – 5. All speakers reported using English in their daily life on a regular basis, both personally and professionally.

Table 4
L1 Spanish L2 English participants' biodata

Speaker	Age	POB	AOL English	Age of arrival to	
				USA	English SRP
S1	28	Mexico	Kindergarten (briefly)/21	21	4, 5, 5, 4
S2	41	Mexico	7	31	6, 5.5, 6, 6
S3	29	Mexico	9	20	6, 5, 6, 5
S4	26	Mexico	15	17	4, 5, 5, 4
S5	39	Mexico	3	28	5, 5, 6, 4

*scores indicate self-ratings in: speaking, listening, reading, writing

5.3. Instruments and procedure

Three tasks were completed by all participants: a narrative task (NT), a sentence-reading task (SRT), and a nonce words reading task (NWRT). This approach was motivated by previous findings related to style effects on speech production. In the NT, participants were shown a five-minute silent animation clip about a woman and a man running into each other at a bus stop and were asked to describe it in their HL, in English and in Spanish. This task elicits data in the most spontaneous speech style possible in a controlled setting, while allowing us to gather data produced in all three relevant languages (inspired by insight in Cabrelli Amaro, 2013). The SRT consisted of 64 short sentences in Spanish. Each phrase contained one to three target words to test /ptk/ production, with words housing instances of /ptk/ ranging in length from two to four syllables. The controlled aspect of the task helped to gather a uniform number of tokens from all speakers and compare productions in controlled speech versus those in spontaneous speech. In the NWRT, 44 nonce items that ranged in length from two to four syllables were tested (e.g., *noca*, *mítabusa*; taken from Face, 2005). The nonce words were embedded in the carrier phrase *Yo digo __ para ti* (“I say __ for you”) to avoid listing intonation.

Data collection was carried out in quiet locations on two large university campuses in the Midwest region of the United States, where participants individually met with the first author. They first filled out the

previously described questionnaires and then completed the NT. Prior to each iteration of the NT, participants were addressed in the language of interest in order to trigger a specific language mode (see Grosjean, 1998). Next, the speakers were asked to complete the SRT before concluding with the NWRT.

5.4. Analysis

The recorded data were analyzed with *Praat* (Boersma & Weenink, 2016), through which VOT duration was measured for all instances of /ptk/ in both word-initial and word-medial stressed position (for comments on positional effects on /ptk/, see Torreira & Ernestus, 2011; Zampini, 2019). Mean and standard deviations were calculated using R statistical software (R Core Team, 2017). Once the acoustic analysis was complete, we fit two Linear Mixed Effects Models (LMEMs) to determine the effect of speaker group on phoneme: Model 1 assumed that only phoneme (i.e., /ptk/), would influence VOT measures; Model 2 assumed that both phoneme and language (i.e., Ukrainian, Polish, English, Spanish) would influence VOT measures. In order to test the significance of the language spoken, we conducted a likelihood ratio test between these two models, which under the null hypothesis follows a chi-squared distribution with 3 degrees of freedom and a p -value of < 0.05 . Given this result showing that both phoneme and language indeed significantly affect VOT, Model 2 was selected as optimal. Therefore, the Model 2 approach was used for the entire analysis and allowed us to determine whether there were any statistically significant differences between the means of the four groups of speakers in English and Spanish, while also accounting for inter-participant variation. The variables used in the analysis include speaker, language, phoneme, and task type.⁶ In the LMEM, speaker is used as a random effect, and phoneme and language are fixed effects.

As with the LMEMs run for speaker group effect on phoneme, we used a similar approach to determine the effect of task type on phoneme: Model 1 assumed that task type (i.e. NT, SRT, NWRT) would not influence VOT measures whereas Model 2 assumed that task type would influence VOT measures, given the speakers' dominant language and phoneme. To test the significance of task type, we conducted a likelihood ratio test between Model 1 and Model 2, which under the null hypothesis follows a chi-squared distribution with 2 degrees of freedom and a p -value of < 0.05 . Based on the results of the likelihood ratio test showing that task type does have an effect on VOT measures, Model 2 was selected as optimal and used throughout the analysis to determine the effect of task type on VOT measures according to phoneme.

6. Results

This section reports the results of the data analysis and is organized according to the research questions presented previously in (1) and (2). First, we present the basis for comparison for English VOT of /ptk/ for all four groups. Next, we present mean VOT values for both control groups, the L1 English L2 Spanish group, and the L1 Spanish L2 English group. Following this is the experimental group data for both Ukrainian HSs and Polish HSs for all languages and tasks. The results section concludes with two subsections including intergroup comparisons of VOT values in Spanish for all four speaker groups, as well as the results of the inferential statistical analysis. Presenting the data in this way allows us to first establish VOT values in English and Spanish from L1 speakers of these languages, which, in turn, can be used as points of comparison when examining VOT values for Ukrainian HSs and Polish HSs across all three of their languages: the HL, the DL, and the L3. We then consider the effect of task type on VOT values for speakers from all groups. The final subsection reports the results of our inferential statistical modelling with respect to the effect of language and task type on VOT values.

6.1. English VOT productions

Regarding VOT baselines for /ptk/ in English for speakers from all groups, Table 5 and Figure 2 below show that all speakers produce long-lag VOT values in English. The L1 Spanish speakers' productions differed the most from the realizations of the L1 English speakers, while the Polish HSs' results approximated them the most.

⁶ Word stress, position within the word, and syllable type were entered as factors in the LMEMs, but will not be addressed in this paper.

Table 5
 Mean VOT values (ms) in English for all speaker groups

Group	Phoneme	Mean / SD	Phoneme total
Ukr HSs	/p/	58.2 / 22.4	10
	/t/	62.8 / 34.7	46
	/k/	54.8 / 13.6	28
Polish HSs	/p/	43.5 / 23.6	27
	/t/	68.3 / 27.7	55
	/k/	58.4 / 25.8	46
L1 English	/p/	53.6 / 26.8	6
	/t/	76.4 / 37.4	20
	/k/	58.7 / 24.8	17
L1 Spanish	/p/	40.2 / 24.3	25
	/t/	49.4 / 22.5	53
	/k/	64.6 / 27.3	48

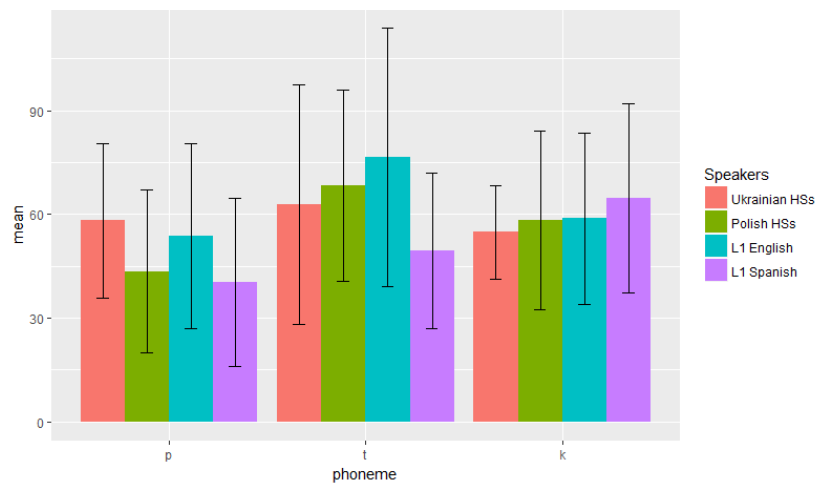


Figure 2. Mean VOT values (ms) in English for all speaker groups

The following subsection on control groups include mean VOT values for English and all three tasks in Spanish. In all tables that follow, statistically significant effects are marked with an asterisk (*) with all p -values at <0.05 . After a complete presentation of the results for the control groups, the next subsection details the results for both experimental groups, the Ukrainian HSs and the Polish HSs, with data from the HL, the DL (i.e., English), and L3 Spanish.

6.2. Control groups

6.2.1. L1 English L2 Spanish speakers

Table 6 summarizes voiceless stop productions by L1 English speakers for /ptk/ in English, as well as for all three tasks in Spanish. As seen in the table, /ptk/ were produced with long-lag VOTs in all instances in both English and Spanish, aligning with monolingual English speaker norms (Lisker & Abramson, 1964; Nagy & Kochetov, 2013). All three stops have the shortest VOTs in the SRT, which may indicate that this is the most familiar speech style for this group of speakers, who are more acquainted with reading in their L2 than actively speaking it.

Table 6
Mean VOT values (ms) for L1 English, L2 Spanish speakers

Language/Task	Phoneme	Mean / SD	Phoneme total
L1 English	/p/	53.6 / 26.8	6
	/t/	76.4 / 37.4	20
	/k/	58.7 / 24.8	17
L2 Spanish NT	/p/*	52.5 / 27.1	45
	/t/*	57.7 / 30.6	33
	/k/	58.1 / 36.6	36
L2 Spanish SRT	/p/*	41.5 / 27	182
	/t/*	47 / 26.7	220
	/k/	54.2 / 28.3	164
L2 Spanish NWRT	/p/*	60.5 / 29	45
	/t/*	56.2 / 29.7	95
	/k/	55.8 / 22.5	45

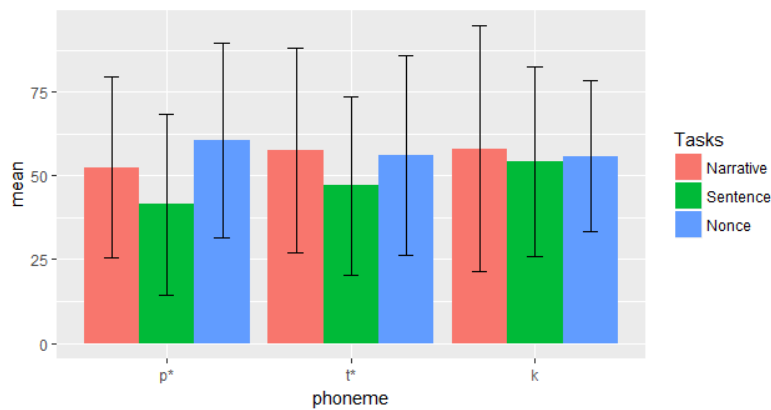


Figure 3. Mean VOT values (ms) in Spanish for L1 English, L2 Spanish speakers

6.2.2. L1 Spanish L2 English speakers

Table 7 includes mean VOT values for /ptk/ productions by L1 Spanish L2 English speakers in English, as well as for all three tasks in Spanish. The production results here suggest that the L1 Spanish speakers' performance becomes at least partially less target-like as tasks become less natural. This trend is most clear when observing the results for /k/ in Figure 4.

Table 7
Mean VOT values (ms) for L1 Spanish L2 English speakers

Language/Task	Phoneme	Mean / SD	Phoneme Total
L2 English	/p/	40.2 / 24.3	25
	/t/	49.4 / 22.5	53
	/k/	64.6 / 27.3	48
L1 Spanish NT	/p/	15.6 / 6.5	100
	/t/	18 / 7.1	70
	/k/*	27.9 / 10.8	148
L1 Spanish SRT	/p/	14.9 / 8.1	183
	/t/	17.5 / 7.2	219
	/k/*	30.4 / 9.7	165
L1 Spanish NWRT	/p/	18 / 11.1	45
	/t/	17.6 / 6.7	94
	/k/*	33.6 / 12.7	44

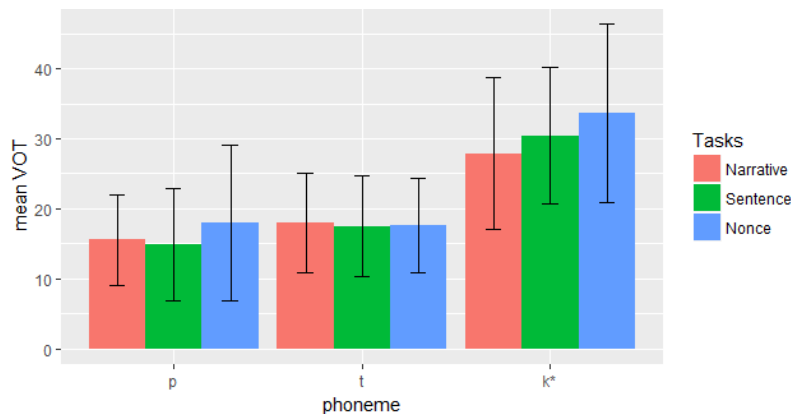


Figure 4. Mean VOT values (ms) in Spanish for L1 Spanish speakers

6.3. Experimental groups

6.3.1. Ukrainian HSs

Table 8 presents Ukrainian HSs' productions of /ptk/ in their HL, in their DL (i.e., English), and in L3 Spanish for all three tasks. As evidenced in this table, Ukrainian HSs' mean VOT productions of voiceless stops in both the HL and the L3 fall within or close to the upper limit of the short-lag category, in line with the average Slavic language values reported in Ringen and Kulikov (2010), and reflecting the L1 Spanish speaker results. A visual representation of the mean VOT values in Spanish for the Ukrainian HSs is illustrated in Figure 5. The raw data results show that as task formality increases, /p/ and /t/ also show an increase in VOT.

Table 8

Mean VOT values (ms) for Ukrainian HSs

Language/Task	Phoneme	Mean / SD	Phoneme Total
HL Ukrainian	/p/	24.2 / 18.9	37
	/t/	23.3 / 12.4	107
	/k/	30.9 / 14.1	55
DL English	/p/	58.2 / 22.4	10
	/t/	62.8 / 34.7	46
	/k/	54.8 / 13.6	28
L3 Spanish NT	/p/*	18.6 / 20.5	46
	/t/*	20.5 / 11.4	51
	/k/	31.5 / 10.8	65
L3 Spanish SRT	/p/*	20.3 / 10.2	215
	/t/*	19.7 / 9.6	262
	/k/	33.5 / 13.1	196
L3 Spanish NWRT	/p/*	25.2 / 15.4	54
	/t/*	23.6 / 15.7	114
	/k/	31.4 / 10.8	54

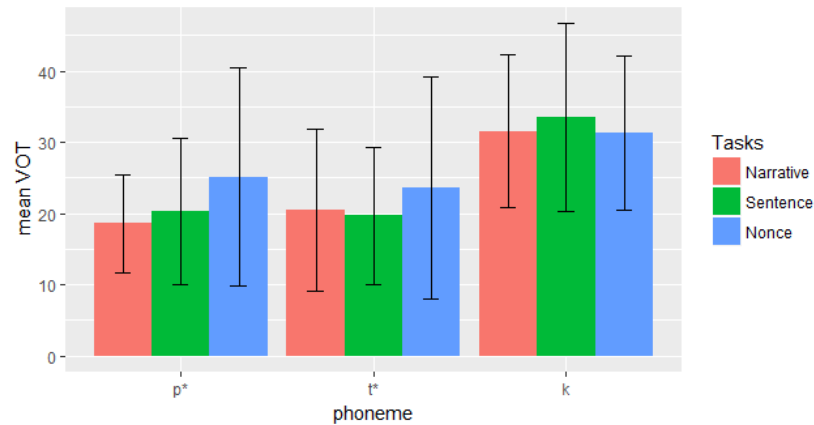


Figure 5. Mean VOT values (ms) in Spanish for Ukrainian HSs

6.3.2. Polish HSs

Table 9 summarizes Polish HSs’ mean VOT values for /ptk/ in their HL, DL (i.e., English), and Spanish for all three tasks. In contrast to the Ukrainian HSs, the Polish HSs’ VOT productions of /ptk/ are not consistently realized with short-lag. The phoneme /p/ is realized with a short-lag VOT in the NT and SRT, and /t/ in the SRT and NWRT; however, other segments show long-lag VOT values, exhibiting evidence of influence of both the HL and the DL. A visual representation of the mean VOT values in Spanish for the Polish HSs is displayed in Figure 6. While /p/ shows an increase in VOT as tasks become more formal, /t/ and /k/ decrease in VOT as elicitation becomes more controlled.

Table 9
Mean VOT values (ms) for Polish HSs

Language/Task	Phoneme	Mean / SD	Phoneme Total
HL Polish	/p/	29.3 / 16.5	76
	/t/	27.3 / 11.1	123
	/k/	36.9 / 15.4	82
DL English	/p/	43.5 / 23.6	27
	/t/	68.3 / 27.7	55
	/k/	58.4 / 25.8	46
L3 Spanish NT	/p/*	28.6 / 17.9	65
	/t/*	42.7 / 22.6	73
	/k/*	53.6 / 25.8	94
L3 Spanish SRT	/p/*	33.7 / 19.4	401
	/t/*	33.2 / 18.6	472
	/k/*	49.4 / 22.1	350
L3 Spanish NWRT	/p/*	39.6 / 22.7	100
	/t/*	32.2 / 18.8	206
	/k/*	44.8 / 19	97

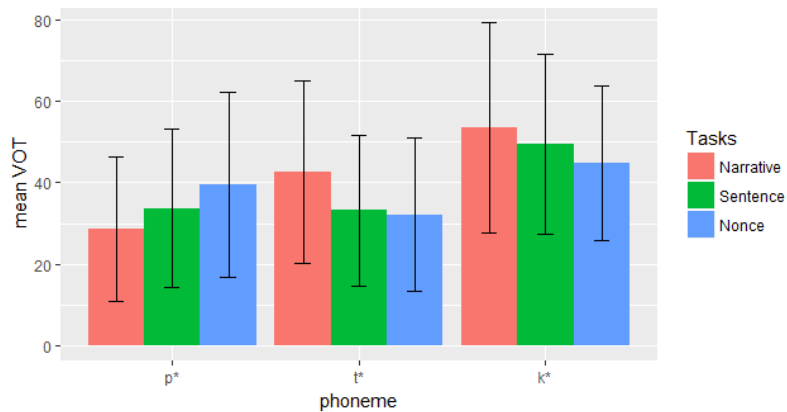


Figure 6. Mean VOT values (ms) in Spanish for Polish HSs

6.4. Intergroup comparisons

Figure 7 summarizes the productions of Spanish /ptk/ by all four groups in each of the three tasks. The L1 Spanish speakers produced the lowest VOT values in all three tasks with one exception: in the NWRT, the Ukrainian HSs displayed the lowest VOT values for the velar segment /k/. The Ukrainian HSs demonstrated the second lowest VOTs, followed by the Polish HSs. The L1 English speakers produced all segments in the three tasks with the longest VOT durations.

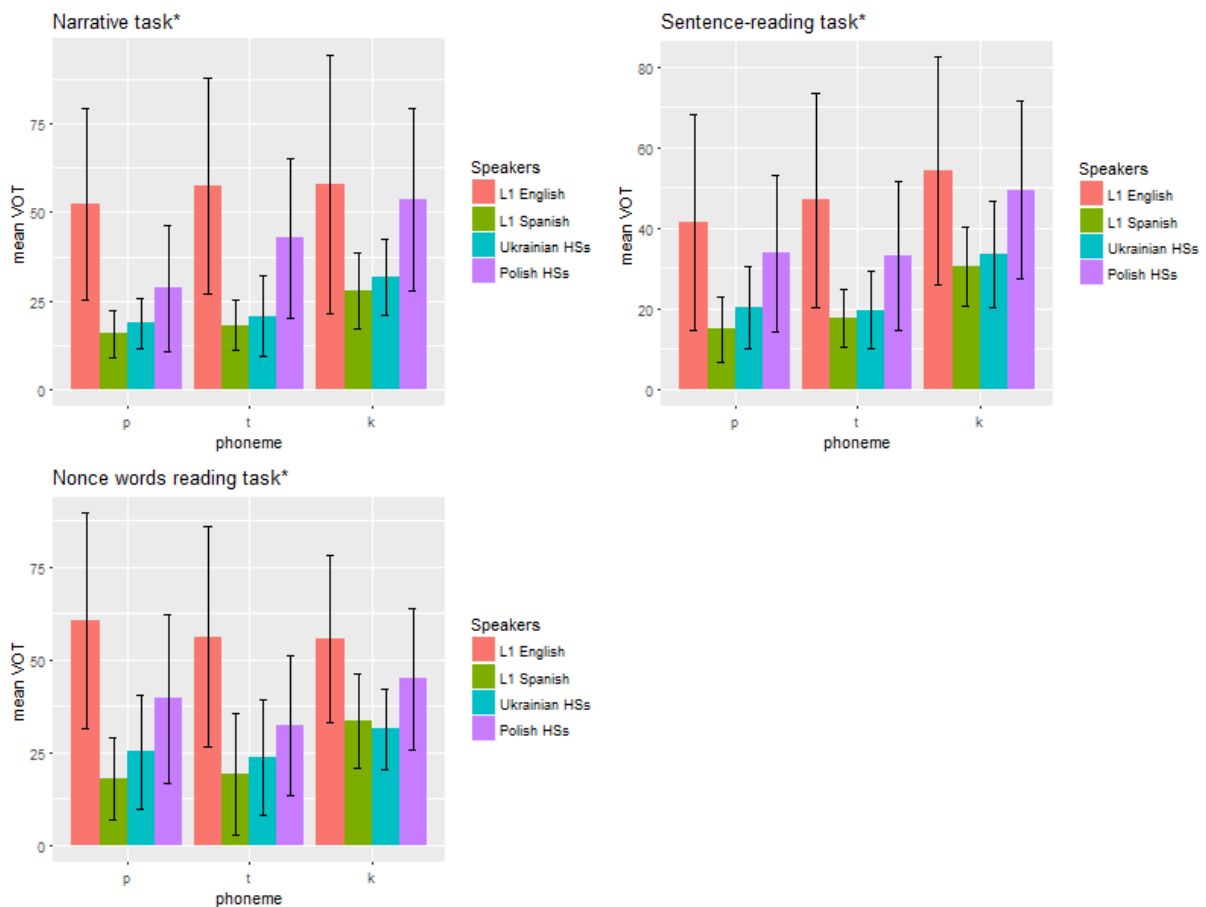


Figure 7. Mean VOT (ms) values in Spanish for all four speaker groups. Statistical significance of task type is indicated with an asterisk (*).

6.5. LMEM Findings

The LMEM revealed that the productions of the four groups were significantly different in all three tasks (NT: $p < 0.05$, SRT: $p < 0.05$, NWRT: $p < 0.05$). For a closer examination of the four groups, we performed a post-hoc Tukey test with a Bonferroni adjustment which examines pairwise mean differences across speakers groups. The results revealed that the L1 English speakers' results are significantly different from those of the L1 Spanish speakers in all three tasks (NT: $p < 0.05$, SRT: $p < 0.05$, NWRT: $p < 0.05$). The Polish HSs differ significantly from the L1 Spanish baseline in the NT ($p < 0.05$) and SRT ($p < 0.05$). The Ukrainian HSs' productions do not differ significantly from those of the L1 Spanish speakers in any of the tasks ($p > 0.05$), thus most closely approximating the control group's VOT values. The following subsections and tables further detail the results of the LMEM for each task, supporting the descriptive analysis.

6.5.1. Narration Task

Table 10 identifies all variables incorporated in the model and their significance for the NT. Note that phoneme /p/ and L1 Spanish were treated as the baselines to which all other variables were compared. The p -values in Table 10 indicate the significant effect of /t/ and /k/ when compared to /p/. Both L1 English speakers and Polish HSs show a significant effect when compared to the L1 Spanish speaker profile. VOT values of Ukrainian HSs are not significantly different from those of the L1 Spanish group.

Table 10
Results for the NT (Speakers = 27; Number of observations = 826)

	Estimate	SE	t	p
Intercept	14.340	5.590	2.566	<0.05
/t/	5.198	1.509	3.445	<0.05*
/k/	14.723	1.356	10.856	<0.05*
L1 English	38.375	7.944	4.831	<0.05*
Heritage Polish	21.890	6.747	3.244	<0.05*
Heritage Ukrainian	3.796	7.563	0.502	>0.05

We further conducted a post-hoc Tukey test to compare the VOT measure differences between the various speaker groups in the NT. The results in Table 11 show that all pairwise comparisons are significant with the exception of heritage Ukrainian versus L1 Spanish and heritage Polish versus L1 English. Based on these results, VOT trends are present among the four speaker groups, where the speakers of heritage Ukrainian are most closely approximating the short-lag VOT of the Spanish control group and the remaining two groups show more divergence from this trend in Spanish.

Table 11
Results of post-hoc Tukey test for the NT

	Estimate	SE	z	p
L1 English – L1 Spanish	38.375	7.944	4.831	<0.05*
Heritage Polish – L1 Spanish	21.890	6.747	3.244	<0.05*
Heritage Ukrainian – L1 Spanish	3.796	7.563	0.502	>0.05
Heritage Polish – L1 English	-16.484	6.892	-2.392	>0.05
Heritage Ukrainian – L1 English	-34.579	7.693	-4.495	<0.05*
Heritage Ukrainian – Heritage Polish	-18.095	6.449	-2.806	<0.05*

6.5.2. Sentence Reading Task

Table 12 identifies all variables incorporated in the model and their significance for the SRT. Again, phoneme /p/ and L1 Spanish were treated as the baselines to which all other variables were compared. For the SRT, results are similar to the NT; however, phoneme /t/ is not significant when compared to the baseline /p/. This result is in line with other research on VOT values of /ptk/, where the velar segment /k/ is, in general, more distinct. Like the NT, both L1 English speakers and Polish HSs effects are significant when compared to the L1 Spanish speaker profile; however, the effect of Ukrainian HSs does not demonstrate significance, meaning their VOT productions reflect those of the L1 Spanish group.

Table 12
Results for the SRT (Speakers = 27; Number of observations = 3,029)

	Estimate	SE	t	p
Intercept	15.7344	4.8776	3.226	<0.05
/t/	1.1494	0.6701	1.715	>0.05
/k/	14.5634	0.7202	20.221	<0.05*
L1 English	26.9268	6.8739	3.917	<0.05*
Heritage Polish	17.6097	5.8624	3.004	<0.05*
Heritage Ukrainian	3.4568	6.5815	0.525	>0.05

A post-hoc Tukey test compared the VOT differences between the four speaker groups for the SRT. The results in Table 13 show similar trends to those of the NT in terms of group pairings; however, the difference between the two HS profiles does not reach significance here.

Table 13
Results of post-hoc Tukey test for the SRT

	Estimate	SE	z	p
L1 English – L1 Spanish	26.927	6.874	3.917	<0.05*
Heritage Polish – L1 Spanish	17.610	5.862	3.004	<0.05*
Heritage Ukrainian – L1 Spanish	3.457	6.582	0.525	>0.05
Heritage Polish – L1 English	-9.317	5.862	-1.589	>0.05
Heritage Ukrainian – L1 English	-23.470	6.582	-3.566	<0.05*
Heritage Ukrainian – Heritage Polish	-14.153	5.517	-2.565	>0.05

6.5.3. Nonce Words Reading Task

Finally, Table 14 shows all variables incorporated and their significance for the NWRT. As with the NT and the SRT, phoneme /p/ and L1 Spanish were treated as the baselines to which all other variables were compared. Trends found in the NWRT are similar to those of the NT in that the *p*-values in Table 14 indicate the significant effect of /t/ and /k/ when compared to /p/. Concerning speaker group, only L1 English speaker effects are significant as compared to the baseline L1 Spanish speaker profile; that is, Polish HSs and Ukrainian HSs effects are not significant, indicating that their VOT productions in this task parallel those of the L1 Spanish group.

Table 14
Results for the NWRT (Speakers = 27; Number of observations = 993)

	Estimate	SE	t	p
Intercept	23.007	5.133	4.482	<0.05
/t/	-3.854	1.337	-2.883	<0.05*
/k/	5.474	1.561	3.508	<0.05*
L1 English	34.941	7.133	4.899	<0.05*
Heritage Polish	14.616	6.083	2.403	>0.05
Heritage Ukrainian	3.521	6.829	0.516	>0.05

A post-hoc Tukey test compared the VOT differences between the four speaker groups for the NWRT. The results are in Table 15, where we notice that the L1 English versus L1 Spanish difference is most salient, but that the two heritage groups are not significantly different from the L1 Spanish group. Both Ukrainian HSs and Polish HSs, however, are significantly different from L1 English speakers, suggesting that the heritage groups have an “advantage” over L1 English speakers when producing VOT in Spanish, especially since some researchers suggest that employing a nonce word reading task is most effective in determining phonological awareness; that is, previous knowledge of lexical items does not interfere with the results, ultimately levelling the task for all speakers.

Table 15
Results of post-hoc Tukey test for the NWRT

	Estimate	SE	z	p
L1 English – L1 Spanish	34.941	7.133	4.899	<0.05*
Heritage Polish – L1 Spanish	14.616	6.083	2.403	>0.05
Heritage Ukrainian – L1 Spanish	3.521	6.829	0.516	>0.05
Heritage Polish – L1 English	-20.325	6.083	-3.341	<0.05*
Heritage Ukrainian – L1 English	-31.419	6.829	-4.601	<0.05*
Heritage Ukrainian – Heritage Polish	-11.095	5.723	-1.938	>0.05

7. Discussion

7.1. Influence of HL/DL on L3 VOT

The Ukrainian HSs produced Spanish /ptk/ with short-lag VOT in all three tasks, potentially relying on the knowledge of their HL, where they also produced the three voiceless stops as short-lag. This finding differentiates itself from the one in Llama and López-Morelo (2016), where the DL, and not the HL, had a greater influence on the production of L3 French voiceless stops. The Polish HSs, however, produced some instances of Spanish /ptk/ as unaspirated stops and some as long-lag, showing evidence of features of both the HL and the DL. While we found evidence of a separate short-lag category for HL stops and a long-lag category for DL stops, the Polish HSs did not exclusively rely on only one category in the production of L3 segments. As suggested by Llama and López-Morelo (2016), this finding may imply that the Polish HSs are mimicking the values that they hear from their classmates (particularly in the production of /k/), who serve as their main source of L3 input; however, when looking at the production of the Spanish /ptk/ by the L1 English speakers, who produced all three stops as aspirated, this argument may not be completely valid. Alternatively, it is possible that the Polish HSs perceive /p/ and /t/ as structurally similar to Polish, but /k/ as structurally similar to English. As mentioned previously, the participants in Llama and López-Morelo (2016) were adolescent HSs, whereas the majority of HSs in the current study are young adults. Several studies have shown that adult speech development differs from that of children and adolescents (e.g., Baker et al., 2008; Brown, 2000; Granena & Long, 2013; Kopečková et al., 2019; Long, 1990; Stoel-Gammon et al., 1994), which could potentially explain the difference in our results. The majority of the younger participants here were enrolled in a university-level Spanish course and could have potentially experienced the effects of classmate input in Spanish such as those in Llama and López-Morelo (2016); however, the older participants were not. Therefore, more research is needed to tease apart the influences of age and exposure to classmates in order to determine the validity of this claim.

According to Kupske (2016), languages in contact often interact in a state of continuous movement, and as a result, language attrition of some aspects of the L1 may occur due to a speaker's abilities in another language. The effects of language attrition on VOT were confirmed by Schereschewsky et al. (2019), where L1 VOT productions by bilingual speakers, L1 Brazilian Portuguese L2 English, and trilingual speakers, L1 Brazilian Portuguese L2 English L3 German, were modified when compared with monolingual Brazilian Portuguese VOT values. This conclusion highlights the multidirectional nature of language transfer in multilinguals. With respect to the differential treatment of /k/ by the Polish HSs, some previous studies on VOT with L2 speakers show that the velar segment is first to exhibit cross-linguistic influence. For example, Lord (2008) investigated VOT attrition of /ptk/ in the L1 of L1 English L2 Spanish speakers and L1 Spanish L2 English speakers and found that the velar segment /k/ was the only segment that continuously showed modified VOT values in the L1 for L1 English L2 Spanish speakers. Bilabial /p/ and dental /t/ VOT values, however, remained similar to those produced by monolingual English speakers. In addition, Alves et al. (2019) found that the velar segment /k/ was realized with a semi-aspirated production even in monolingual speakers of Spanish, with a mean VOT value of /k/ of 46.61 ms. Therefore, it is possible that the compromised VOT productions of /k/ in L3 Spanish produced by the Polish HSs have been influenced by their L2 English; this is further evidence that the velar segment is first to present signs of attrition.

When determining HL/DL influence on L3 VOT production, it is important to note the sample size of each group of participants. The data presented thus far in this section highlights the HSs' short-lag VOT values in their L3 Spanish, suggesting influence from their HL, also characterized by short-lag VOT, instead of influence from their DL, English, where long-lag VOTs are the norm. Casillas (2021) points out that similar studies in the social sciences are often underpowered due to the relatively small participant pool (see also Brysbaert, 2021; Ellis, 2010; Plonsky & Oswald, 2014). Since research on the intersection of HL and L3 phonology is in its

incipient stages and is largely exploratory at this point in time, the participant pool for the current study is relatively small; however, this research presents a useful point of departure for further exploration in this field, and the results support future directions for HS and L3 phonology.

7.2. Experimental group divergence

Since our hypotheses predicted that the Ukrainian HSs and the Polish HSs would behave similarly, the fact that the Ukrainian and Polish HSs produced some different results in their productions of Spanish /ptk/ has prompted us to look for additional explanations. One potential factor that could contribute to this difference may be the speakers' different levels of proficiency in Spanish. Ukrainian HSs demonstrated at least an intermediate level of proficiency in their L3, but the Polish HS group, on the other hand, had four speakers with a very low level of Spanish proficiency. As shown by Hammarberg and Hammarberg (2005) and Wrembel (2010), the types of transfers observed during various stages of L3 acquisition are different and continue to change as speakers become more proficient L3 users. Although our study does not aim to investigate HSs' development in their L3 over time, it may provide clues as to which language plays a bigger role in the early stages of L3 production. It is possible that during the initial stages of L3 acquisition, HSs are more reliant on their DL, but once they become more proficient in L3 Spanish, the link is severed. Alternatively, when considering L2 studies (e.g., González-Bueno, 1997), which show that typical L1 English L2 Spanish learners are producing aspirated stops even at intermediate and advanced levels unless they receive explicit instruction, the Ukrainian HSs' results in particular may suggest that these speakers are helped by their HL, and that their unaspirated productions of Spanish /ptk/ are not simply due to their development as Spanish learners. Nonetheless, without more research on HSs at different acquisitional stages of their L3, it is difficult to state with certainty whether the increased target-like productions in the Ukrainian HSs is due to level of Spanish development or positive influence from HL's short-lag feature.

Another possible explanation for the discrepancy in the Ukrainian and Polish HSs' results are the HSs' ties with their HL communities. Nagy and Kochetov (2013), for example, showed that HS communities are highly diverse, and each group may have their own language norms, which may be undergoing generational shifts. On average, the Polish HSs' VOTs of the Polish stops were slightly greater than those of the Ukrainian HSs in Ukrainian. If the Polish HSs are shifting to longer VOTs in Polish across generations, this phenomenon may influence these speakers' VOT acquisition in other languages; however, since this investigation does not aim to study the community ties of the HSs, nor does it have the evidence to fully support this claim, this statement merely serves as a call for future research.

Overall, our data do emphasize that Ukrainian and Polish HSs' Spanish VOTs were shorter than those of the L2 Spanish group. This implies that exposure to the short-lag feature from an HL does appear to help HSs achieve a more target-like production of voiceless stops in comparison to L2 learners who are only familiar with the long-lag category.

7.3. Effect of task type

Task type clearly affected the VOTs of Spanish voiceless stops. Concerning the Ukrainian HSs, while the highest VOT values appeared in the two controlled tasks, the difference was small in comparison to the spontaneous elicitation and still did not place any of the stops into the long-lag category; however, the results did show that as tasks became more formal, their VOTs increased, a pattern that was also observed with L1 Spanish speakers. Perhaps, this phenomenon also relates to the speakers' proficiency level in Spanish, signaling that as speakers become more proficient in their L3, speaking becomes the most natural speech style.

In the Polish HSs' data, the bilabial segment /p/ showed a gradual increase in VOT as task formality increased, mimicking the general trends seen in the L1 Spanish and Ukrainian HSs' data. The phonemes /t/ and /k/, on the other hand, displayed an inverse relationship in comparison to /p/. What is particularly intriguing is that /t/ was produced as long-lag in the NT, but as short-lag in the NWRT task, possibly suggesting that underlyingly, it is classified as short-lag in the productive grammars of these speakers. Although Polish HSs may be implicitly classifying /t/ differently than L2 learners, overall, this finding seems to support Llama and López-Morelo's (2016) claim that HSs learning an L3 may be mimicking their L2 classmates' VOT productions. The /t/ and /k/ results also seem to support our claim that more controlled tasks better reflect the learners' use of L3 Spanish at lower proficiency levels. The Polish HSs' results coincide closely with those of the L1 English speakers, who produced the shortest VOTs in the SRT. Since the two groups have comparable mean SRP scores, which are lower than those of the Ukrainian HSs, the results suggest that this speech style is the most familiar for these language learners, backing Tarone's (1979) observation that L2 learners produce more

target-like results in formal speech; however, unlike Polish HSs, the L1 English speakers produced the Spanish /ptk/ as long-lag in all three tasks, presenting clear evidence of transfer of the long-lag feature from their L1, regardless of task formality.

7.4. Theoretical implications

Since our results demonstrate evidence of both facilitative and non-facilitative transfer from the HL and the DL, we believe that our findings may shed light on the Linguistic Proximity Model (LPM) (Westergaard et al., 2016). The LPM, which argues that all previously learned languages are available throughout the L3 acquisition process, allows us to account for the differences observed in the Ukrainian and Polish HSs' data. According to the LPM, cross-linguistic influence will take place when a linguistic property in the L3 input displays an abstract structural similarity to the structure of previously acquired languages. In order for cross-linguistic influence to be facilitative, learners must have received sufficient L3 input to perceive linguistic similarities at an abstract level. Without sufficient exposure to an L3, learners are relying on superficial similarities, which results in non-facilitative transfer. It may be possible that due to higher proficiency in L3 Spanish, the Ukrainian HSs perceived L3 Spanish /ptk/ as structurally similar to Ukrainian voiceless stops, which triggered influence of the short-lag feature from the HL. While the Polish HSs also might have perceived /p/ and /t/ as structurally similar to Polish, resulting in mainly short-lag values for these segments, due to their lower L3 proficiency level, they appear to have perceived /k/ as more similar to English at a superficial level, which led to increased VOT values for this segment. Our theoretical claims support the LPM by providing evidence of transfer from both the HL and the DL to an L3, which depends on the quantity of L3 input.

7.5. Pedagogical implications

The results from this study have important pedagogical implications for instructors, more specifically, Spanish instructors in the world language classroom who have HSs of HLs other than Spanish as students. In other words, given that L3 learners of Spanish are able to draw on phonological characteristics from both their HL (in our case, Ukrainian or Polish) and their DL (in our case, English), instructors' awareness of the linguistic history and abilities of their students can facilitate the connections that they make between the target language and the students' other languages when providing pronunciation instruction. In this case, bringing this conversation to the level of the student, making a connection between the pronunciation of /ptk/ in Spanish and in the HL rather than the DL, highlights the similarities between their HL and L3 and further supports their acquisition of a target-like realization of /ptk/. More broadly, the life experiences of students have the potential to make valuable contributions to overall student success and proficiency. Language instructors can design and modify their instruction by tapping into this resource, ultimately making the student learning experience more positive and productive.

8. Conclusion

The purpose of this study was to describe the acquisition of L3 Spanish voiceless stops by Ukrainian and Polish HSs, thus contributing to the fields of phonetics and phonology, language contact, and multilingualism. It allowed us to establish a comparison between languages that, to our knowledge, have never been examined together using our type of methodological approach. The conclusions provide critical information about the development of Slavic HSs' sound systems as L3 learners by describing VOT values of voiceless stops of Ukrainian and Polish HSs in their full set of languages, and make significant contributions to the growing field of L3 phonetics and phonology within the specific context of HSs of Slavic languages. In sum, we hope that our methodological and analytical approach and the issues we have raised inspire future investigations on other language combinations that will allow us to broaden our knowledge of overarching empirical and theoretical issues related to L3 phonology and HL research.

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Margaryta Bondarenko, University of Wisconsin-Madison
margaryta.bondarenko@mheducation.com

- EN** **Margaryta Bondarenko** is a product developer at McGraw Hill, where she applies her research experience to the development of motivating, dynamic, and culturally-authentic introductory and intermediate Spanish programs, helping students build confidence and achieve success in their language-learning journey. Her interests include phonetics, phonology, second and third language acquisition, applied linguistics, heritage languages, language pedagogy, educational technology, e-learning, and gamified learning.
- ES** **Margaryta Bondarenko** es desarrolladora de productos en McGraw Hill, donde aplica su experiencia investigadora al desarrollo de programas de español básicos e intermedios motivadores, dinámicos y culturalmente auténticos, que ayudan al alumnado a ganar confianza y alcanzar el éxito en su camino al aprendizaje de idiomas. Sus intereses incluyen la fonética, la fonología, la adquisición de un segundo y tercer idioma, la lingüística aplicada, las lenguas de herencia, la enseñanza de lenguas, la tecnología educativa, el e-learning y la gamificación.
- IT** **Margaryta Bondarenko** è una sviluppatrice di prodotto presso la McGraw Hill, dove applica la sua esperienza di ricerca allo sviluppo di corsi di spagnolo di livello base e di livello intermedio motivanti, dinamici e culturalmente autentici, e che hanno l'obiettivo di aiutare gli studenti ad acquisire sicurezza e ad avere successo nel loro percorso di apprendimento linguistico. I suoi interessi di ricerca riguardano la fonetica, la fonologia, l'acquisizione delle lingue seconde e terze, la linguistica applicata, le lingue ereditarie, la didattica delle lingue, le tecnologie per l'istruzione, l'apprendimento online e l'apprendimento ludico.

Brianna Butera, University of Memphis
bjbutera@memphis.edu

- EN** | **Brianna Butera** is an assistant professor of Spanish in the Department of World Languages and Literatures at the University of Memphis. She specializes in pronunciation variation across the Spanish-speaking world and measuring language variability using acoustic analysis. Her most recent research focuses on variation in the Spanish of heritage speakers and inclusive pedagogy in the heritage speaker classroom.
- ES** | **Brianna Butera** es profesora de español en el Departamento de Lenguas y Literaturas de la Universidad de Memphis. Se ha especializado en la variación de la pronunciación en el mundo hispanohablante y en la medición de la variabilidad lingüística mediante el análisis acústico. Su investigación más reciente se centra en la variación del español de los hablantes de herencia y la pedagogía inclusiva en el aula de hablantes de herencia.
- IT** | **Brianna Butera** è ricercatrice di spagnolo presso il Dipartimento di World Languages & Literatures della University of Memphis. È specializzata nella variazione di pronuncia all'interno del mondo ispanofono e nella misurazione della variabilità del linguaggio attraverso l'uso dell'analisi acustica. Le sue ricerche più recenti sono centrate sulla variazione dello spagnolo nei parlanti ereditari e sulla pedagogia inclusiva nelle classi composte da parlanti ereditari

Rajiv Rao, University of Wisconsin-Madison
rgrao@wisc.edu

- EN** | **Rajiv Rao** is an associate professor of Spanish in the Department of Spanish and Portuguese and the current Director of the Language Sciences Program at the University of Wisconsin-Madison. His primary research streams deal with segmental and suprasegmental phonetics and phonology as they pertain to heritage speakers and Afro-Hispanic varieties, among other areas related to sociolinguistics and language variation and change. He is also interested in the second language acquisition of Spanish phonetics and phonology and in approaches to teaching Spanish pronunciation.
- ES** | **Rajiv Rao** es profesor titular de español en el Departamento de Español y Portugués, y es actualmente el director del Programa de Ciencias del Lenguaje de la Universidad de Wisconsin-Madison. Sus principales líneas de investigación se centran en la fonética y fonología segmental y suprasegmental en relación con los hablantes de herencia y las variedades afrohispanicas, entre otras áreas relacionadas con la sociolingüística y la variación y el cambio lingüísticos. También está interesado en la adquisición de la fonética y la fonología del español como segunda lengua y en las estrategias de enseñanza de la pronunciación del español.
- IT** | **Rajiv Rao** è professore associato presso il Dipartimento di Spanish e Portuguese ed è direttore del Programma di Scienze del Linguaggio presso la University of Wisconsin-Madison. I suoi principali filoni di ricerca riguardano la fonologia e la fonetica segmentale e soprasedimentale relative ai parlanti di lingue ereditarie e alle varietà afro-ispatiche, tra gli altri ambiti relativi alla sociolingüística e alla variazione e al cambio linguistici. Si interessa anche dell'acquisizione della fonetica e della fonologia spagnola negli apprendenti non-nativi e delle strategie di insegnamento della pronuncia spagnola.