Regressive Cross-Linguistic Influence in Multilingual Speech Rhythm: The Role of Language Similarity

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Abstract

While previous work on multilingual speech rhythm has found evidence of progressive cross-linguistic influence of a first or second language (L1, L2) on a third language (L3), regressive cross-linguistic influence (rCLI) in rhythm remains understudied. In the current study, we tested the roles of order of acquisition and of language similarity in shaping rCLI from syllable-timed Spanish as L3 to stress-timed English and German as L1/L2. In a picture narration task, adult sequential trilinguals (L1 English-L2 German-L3 Spanish, L1 German-L2 English-L3 Spanish) and sequential bilingual controls (L1 English-L2 German, L1 German-L2 English) produced semi-spontaneous speech in each of their languages, which was analyzed in terms of the rhythm metric VarcoV. Results showed evidence of rCLI in English (the typologically more similar language to Spanish) but no evidence of rCLI in German; however, rCLI in English was found only when English was the L1. On the basis of these findings, we propose the Similarity Convergence Hypothesis (SCH), which claims that previously acquired languages that are more similar to a later-acquired language are relatively more vulnerable to rCLI from this language.

Keywords: speech rhythm, cross-linguistic influence, regressive cross-linguistic influence, speech production, prosody, English, German, Spanish, VarcoV, cross-linguistic similarity, order of acquisition

1 Introduction

In this chapter, we examine how acquisition of a third language (L3) may influence a multilingual's previously-acquired first language (L1) and second language (L2), a type of cross-linguistic influence (CLI) known as *regressive* CLI (henceforth, rCLI). While research on L3 acquisition over the past two decades has been concerned primarily with initial state transfer and early stages of target language development, including *progressive* CLI (pCLI) from the L1/L2 to the L3, research on bilingualism has increasingly focused on rCLI (e.g., Chang, 2010, 2019a; de Leeuw et al., 2012, 2018), paving the way for investigations of rCLI in both early and advanced stages of multilingualism. Nevertheless, rCLI remains understudied in the field of multilingualism, leaving us with an incomplete picture of multilingual processing.

In regard to linguistic and experiential factors that could influence rCLI in multilingualism, the L3 literature points to two as potentially relevant: age/order of ac-

quisition and language similarity. First, it has been hypothesized that a late age of L2 acquisition renders the L2 more vulnerable than the L1 to phonological rCLI from the L3 (Cabrelli Amaro & Rothman, 2010; see §2.1); age of L2 acquisition has also been argued to predict pCLI in trilinguals (Bardel & Falk, 2007, 2012; Falk & Bardel, 2010, 2011; Brown, 2020). A second possibility is that, in the same way that age/order of acquisition has been shown to influence both pCLI and rCLI, typological (i.e., structural) similarity between languages could also affect both pCLI and rCLI. While the exact role of typological similarity in facilitating rCLI remains unclear, it is thought to play an important role in pCLI (Rothman, 2010, 2011, 2013, 2015; Rothman & Cabrelli Amaro, 2010; Giancaspro et al., 2015; Westergaard et al., 2017).

The current study considers both of these factors in examining phonological rCLI in high-proficiency sequential trilinguals who speak rhythmically disparate languages (English and German as L1/L2, Spanish as L3). In the remainder of this chapter, we report acoustic data on trilinguals' speech rhythm in each of their languages, which was examined specifically for evidence of rCLI, and discuss the degree to which order of acquisition and/or language similarity can account for the observed patterns of rCLI. Our results lead us to propose a new similarity-based hypothesis—the Similarity Convergence Hypothesis—which we describe in further detail below.

2 Background

2.1 Phonological rCLI

Although there is little work on phonological rCLI in multilinguals, there is a considerable body of research on phonological rCLI in bilinguals, including sequential bilingual adults. Early work in this vein, conducted by Flege and colleagues on French-English and Dutch-English bilinguals (Flege, 1987; Flege & Eefting, 1987), found evidence of convergence in bilinguals' voice onset time (VOT) values across languages, resulting in both L1 and L2 values that were significantly different from those of monolingual controls. Such findings led to the inclusion of rCLI in models of L2 acquisition such as the Speech Learning Model (SLM: Flege, 1980, 1995; Flege et al., 2006). According to the SLM, the phonetic elements of the L1 and L2 exist in a shared phonetic space; as a result, the L1 and L2 systems are able to mutually influence one another, leading to both pCLI and rCLI. Since the development of the SLM, additional research has found evidence of rCLI in both segmental features (e.g., Guion, 2003; Ulbrich, 2014) and suprasegmental features (e.g., Willems, 1982; Mennen, 2004; Ulbrich, 2012) and distinguished between different sources and timelines of rCLI (Chang, 2019b; de Leeuw, 2019). Crucially, what the bilingual literature brings to our attention is that CLI is not unidirectional, based on a strictly progressive relationship between an L1 and L2; the relationship between languages in a bilingual mind is, instead, a complex network.

The network of possibilities for CLI becomes ever more complex when an L3 enters the picture, yet there is scant research exploring phonological rCLI in trilinguals. The few existing studies, including work on vowel production in L1 Polish-L2 Danish-L3 English trilinguals (Sypiańska, 2016), word-final vowel reduction in

Spanish-English bilinguals learning L3 Brazilian Portuguese (Cabrelli Amaro, 2017), VOT perception in L1 Mandarin-L2 English-L3 Spanish trilinguals (Liu et al., 2019), pitch span production in L1 Cantonese-L2 Mandarin-L3 English trilinguals (Han, Tian, and Chen, this volume), and production of word-initial stops by L1 Mandarin-L2 English bilinguals learning L3 Spanish (Zhang, Morales-Front, and Sanz, this volume), differ not only in the phonological features and language triads under investigation, but also in their findings, making it difficult to draw generalizations or formulate predictions concerning phonological rCLI in trilinguals. Additionally, L2-focused models such as the SLM generally do not address CLI in a trilingual context.

To our knowledge, there is only one formal hypothesis regarding phonological rCLI in trilinguals: Cabrelli Amaro and Rothman's (2010) Phonological Permeability Hypothesis (PPH). The PPH claims that phonological systems acquired in adulthood, such as that of a late-acquired L2, are less resistant than L1 phonological systems to CLI from an L3. This claim is based on the assumption that the L1 system, developed in childhood, is fundamentally and neurologically different from that of a later-acquired language, resulting in comparatively greater stability. Therefore, the PPH predicts that phonological rCLI from an L3 is more likely to be found in the L2 than in the L1. This prediction was borne out in Cabrelli Amaro and Rothman's finding of greater rCLI from L3 Brazilian Portuguese in the treatment of Spanish coda consonants in L2 Spanish (sequential English-Spanish bilingual learners) compared to L1 Spanish (simultaneous English-Spanish bilingual learners).

Apart from order of acquisition, a number of other factors have been implicated in rCLI in bilinguals—for example, language use (Mayr et al., 2020; Olson, 2020), exposure to native vs. non-native L1 speech (Mayr et al., 2020), age of reduced contact with the L1 (Bylund, 2009; Ahn et al., 2017), and typological similarity between languages (Schmid & Köpke, 2017). However, we focus here on typological similarity because of the prominent role it has played in both L3 acquisition research generally and attrition research specifically (e.g., Schmid and Köpke, 2017; Mayr et al., 2020). While there are many ways in which one might operationalize the typological similarity between two languages, the Typological Primacy Model (TPM; Rothman, 2011, 2015) articulates a specific proposal in connection with research on the L3 initial state: at the initial stage of L3 acquisition, a linguistic parser deems either the L1 or the L2 as more similar to the L3, by looking first for lexical similarities with the L3, then phonological overlap, then morphological overlap, and finally syntactic overlap. Note that the exact features that play a role within each of these levels of comparison are not specified by the TPM; for example, with respect to phonology, it is unclear if there is a hierarchy among different aspects of phonology that may prioritize a particular aspect such as segmental features or syllable structure. Nevertheless, the TPM makes a clear claim concerning hierarchy among the levels, with the lexicon being primary. Originally proposed to account for the initial stage of L3 acquisition, the TPM's process of determining cross-linguistic similarity is theoretically applicable to later stages of L3 acquisition as well. Thus, we adopt this process for determining cross-linguistic similarity for advanced L3 speakers in the current study.

Notably, typological similarity between languages has been marshalled not only to account for pCLI in L3 acquisition but also to explain rCLI in bilingualism. In re-

gard to rCLI, Schmid and Köpke (2017) claim that a bilingual's L1 is most vulnerable to rCLI—specifically, attrition—in instances where their two languages are relatively similar to each other, as similarity may blur the bilingual's sense of what is and what is not grammatical in their L1 (as opposed to their L2). Given that typological similarity has been implicated in both pCLI in multilingualism and rCLI in bilingualism, it is reasonable to hypothesize that similarity might also play a role in rCLI in multilingualism. In fact, this hypothesis finds support in results of the L3 studies cited above: when these studies found rCLI, it was found to occur between the two most typologically similar languages (Cabrelli Amaro and Rothman, 2010; Schmid and Köpke, 2017; Mayr et al., 2020; Olson, 2020). To our knowledge, however, there are no studies systematically testing the effect of similarity on rCLI in multilingualism.

2.2 Speech Rhythm

2.2.1 Acquisition of Rhythm

Among the various phonological features that could be examined in a study of rCLI in multilingualism, speech rhythm particularly warrants investigation given the overall dearth of L3 research on suprasegmental features (Cabrelli Amaro & Wrembel, 2016; cf. Chan & Chang, 2019). Rhythm refers to the sense of movement in speech, originally thought to derive from the temporally regular repetition of elements perceived as similar—syllables in "syllable-timed" languages, or stressed syllables specifically in "stress-timed" languages. Early theories of speech rhythm (e.g., Abercrombie, 1967) classified languages into distinct stress-timed and syllable-timed categories. However, more recent work has found that speech rhythm is a complex construct involving various phonological properties such as patterns of vowel reduction and the structure and complexity of syllables (Nespor, Shukla, & Mehler, 2011), which has led to the reconceptualization of "stress timing" and "syllable timing" as endpoints on a rhythmic spectrum (Gut, 2010).

As for how rhythm is acquired, L1 rhythm is known to be one of the earliest features of language acquired by infants (Mehler et al., 1988; Nazzi et al., 1998; Minai et al., 2017), although full development of the L1 rhythm system is a process that proceeds incrementally. In this process, syllable timing appears to be the default setting, whereas stress timing is a marked feature acquired at later stages of development. Production of adult-like stress timing is not achieved by monolingual children until the age of 11 or 12 (Polyanskaya & Ordin, 2015); nevertheless, for bilingual children, a rhythmic distinction between their two languages can be detected in their speech by around the age of 4 (Schmidt & Post, 2015).

Acquisition of speech rhythm in a new language after the critical/sensitive period has been reported to be difficult for learners, and non-native-like rhythm has been described as one of the primary factors contributing to a "foreign accent" (Anderson-Hsieh et al., 1992). Research on the acquisition of a stress-timed L2 by adults with a syllable-timed L1 and of a syllable-timed L2 by adults with a stressed-timed L1 has found that, at advanced levels of proficiency, L2 learners show evidence of developing an L2 rhythm that both resembles the target language rhythm to some degree and is distinct from their L1 rhythm, although only in rare instances is this L2

rhythm native-like (Guilbault, 2002; Ordin & Polyanskaya, 2015a). Under the view that linguistic rhythm systems lie on a spectrum, rhythmic differences may also exist between an L1 and L2 belonging to the same broad rhythm class, and in this case significant developments in L2 rhythm are also observed (e.g., Ordin & Polyanskaya, 2015b).

Taken together, studies of L2 rhythm demonstrate that while the L2 rhythm system is unlikely to be native-like, it does tend to be distinct from the L1 rhythm system. Whereas the acquisition of L2 rhythm is relatively well studied, little is known about L3 rhythm. One of the few studies to examine rhythm in multilinguals found evidence of facilitative pCLI from the L2 to the L3 in L2 English-L3 German and L2 German-L3 English speakers (Gut, 2010). However, rCLI in multilingual speech rhythm has not been examined systematically in any published research to our knowledge.

2.2.2 Rhythm Metrics

Over the past three decades, a variety of acoustic metrics of speech rhythm have been proposed, which are all based on a segmentation of the speech stream into vocalic and consonantal intervals. Four common metrics are %V (percent vowel—the sum of vocalic interval durations divided by the total duration of vocalic and consonantal intervals and multiplied by 100; Ramus et al., 1999), ΔV (delta vowel—the standard deviation of vocalic interval durations; Ramus et al., 1999), VarcoV (variation coefficient for vowels—ΔV divided by the mean vocalic interval duration and multiplied by 100; Dellwo, 2006), and nPVI-V (normalized pairwise variability index for vowels—the sum of durational differences between adjacent vocalic intervals divided by the mean vocalic interval duration; Low et al., 2000; Grabe & Low, 2002). In comparison to syllable-timed languages, stress-timed languages are anticipated to show a relatively high degree of variation in both vocalic and consonantal interval durations, due to two recurrent phonological properties: a strong dependence of vowel duration on stress, and a wide range of consonant cluster complexity. The pattern of durational variation associated with stress timing thus tends to lead to relatively low values for %V (Ramus et al., 1999) and relatively high values for ΔV (Ramus et al., 1999), VarcoV (Dellwo, 2006; White and Mattys, 2007), and nPVI-V (Grabe & Low, 2002).

Given that all of the above metrics were originally proposed for the comparative (typological) study of speech rhythm as produced by native speakers—and not for the study of non-native rhythm—White and Mattys (2007) carried out a formal assessment of the metrics' ability to reflect trends in non-native rhythm. Working under the assumption that learners acquiring an L2 that is rhythmically different from their L1 should show an L2 rhythm distinct from both the L1 rhythm and the target L2 rhythm (an assumption that is in line with models of L2 phonological acquisition such as the SLM), White and Mattys collected reading and elicited free speech data from participants with four different language backgrounds: L1 English-L2 Spanish, L1 Spanish-L2 English, L1 English-L2 Dutch, and L1 Dutch-L2 English. Speech was collected in both languages for each participant, and seven different speech rhythm measures were calculated: %V, ΔV, VarcoV, nPVI-V, ΔC and VarcoC (the respective equivalents of ΔV and VarcoV for consonantal intervals), and rPVI-C (raw pair-

wise variability index for consonants). The authors tested the ability of each metric to discriminate "stress-timed" English and Dutch from "syllable-timed" Spanish and French and to quantify the influence of the L1 on L2 rhythm. They found that, overall, VarcoV was the only metric able to both successfully differentiate between rhythm classes and offer a discriminative analysis of non-native rhythm patterns.

Although the above metrics, including VarcoV, are sensitive to register and style and have been criticized as the basis of research aiming to categorize languages into rhythm classes (see, e.g., Arvaniti, 2012), our focus in the current study was not on cross-language differences, but rather on individual differences. Therefore, we were not concerned with register or style effects and designed our study to elicit a consistent speech style within a controlled experimental setting. Our analysis of the elicited speech focused on VarcoV as the target measure as it has been found to be best-suited for investigating individual differences in L2 and L3 rhythm.

2.3 Research Question and Hypotheses

The present study investigated whether order of acquisition and/or typological similarity predicts rCLI in multilingual speech rhythm via a study of intermediate and advanced L3 Spanish speakers with an L1/L2 repertoire of English and German (in either order of acquisition). We tested the following hypotheses as to how these two factors might affect rCLI from the L3.

In regard to order of acquisition (i.e., L1/L2 status), we expected that our results would be in line with the PPH (Cabrelli Amaro & Rothman, 2010), given that the PPH was based on data most closely related to the rhythmic features we focused on in the current study. Thus, we hypothesized that, all other things being equal, the L2 would show more (convergent) rCLI from L3 Spanish than would the L1, resulting in the L2 becoming more similar to the L3 (**Hypothesis 1, H1**).

As for typological similarity with the L3, our hypothesis followed from the TPM, which predicts similarity to facilitate language transfer (leading to convergent CLI). Thus, we hypothesized that, all other things being equal, English—the typologically more similar language to Spanish (for reasons described below)—would show more (convergent) rCLI from L3 Spanish than would German (**Hypothesis 2, H2**). This hypothesis can also be seen as a multilingual extension of Schmid and Köpke's (2017) claim, for bilinguals, that the L1 is most vulnerable to rCLI in those cases where the L1 and L2 are "sufficiently similar to allow some kind of spillover" (p. 653).

Finally, considering H1 and H2 together leads to the prediction that, for L3 Spanish speakers with an L1/L2 repertoire of English and German, the effects of rCLI will be greatest in L2 English, because this is the combination of language and order of acquisition that represents both typological similarity (according to the logic of the TPM) and order of acquisition (according to the logic of the PPH) favoring rCLI from L3 Spanish. Thus, we hypothesized that rCLI would be most evident in the English speech of L1 German-L2 English-L3 Spanish speakers (**Hypothesis 3, H3**).

In order to test these hypotheses (H1, H2, H3), we examined two groups of sequential trilinguals who differed in the order of acquisition of shared first and second languages, targeting a language combination in which the speech rhythms of the L1 and L2 are similar to each other but distinct from the L3—namely, English (L1/L2),

German (L1/L2), and Spanish (L3). The comparison between each trilingual group and a sequential bilingual control group (with the same L1/L2 background but no L3) established whether or not there was rCLI from L3 Spanish in the trilinguals' L1 and/or L2, while the comparison between the two trilingual groups addressed whether rCLI differed according to order of acquisition, typological similarity, or both factors.

Our target language combination was English, German, and Spanish because it satisfied two specific constraints that follow from the hypotheses. First, to be able to detect rCLI from L3 rhythm clearly in either the L1 or L2, the L1 and L2 both needed to be rhythmically distinct from the L3. Our target language combination met this constraint as English and German are both described as stress-timed languages whereas Spanish is described as a syllable-timed language (Nespor et al., 2011). Second, in order to be able to test the role of typological similarity, there needed to be a disparity in typological similarity between the L3 and each of the L1 and L2. Our target language combination met this constraint as well because, in spite of being overall somewhat typologically distant from both Germanic languages, Spanish (a Romance language) is more similar to English. This determination of similarity is based primarily on studies of lexical overlap by Schepens et al. (2012, 2013). Examining the frequency and distribution of cognates across six European languages, these studies demonstrated that Spanish and English share nearly twice as many cognates (both orthographic and phonological) as Spanish and German. A different study of L3 Spanish aspect in learners with English and German as L1/L2 makes the same determination of relative language similarity based on lexical as well as morpho-syntactic overlap (Eibensteiner, 2019). For these reasons, we assumed that English would be perceived by English-German-Spanish trilinguals as more similar to Spanish than German would be.

3 Methods

3.1 Participants

All participants included in the analysis were proficient sequential trilinguals (for the experimental trilingual groups) or bilinguals (for the bilingual control groups), where "sequential" was defined as having acquired the L2 (and L3, as relevant) after the age of 5. Proficiency (in all languages) was demonstrated via a score on the respective LexTALE vocabulary test (Lemhöfer and Broersma, 2012; Izura, Cuetos, and Brysbaert, 2014) that was at least intermediate-level (B1 on the Common European Framework of Reference scale). Participants also had to have no knowledge of other languages besides the target languages (English, German, Spanish), and Spanish had to be the L3 within the language repertoire, based on reported age of acquisition. To reiterate, according to language background data, trilingual participants had acquired Spanish as their L3 (as opposed to their L2 or L1).

Given these requirements, many more participants were recruited for the study than were included in the final sample due to numerous exclusions following a review of background questionnaire data and proficiency scores. In total, 73 participants completed the study, and 20 of these participants (13 female, 7 male; mean age = 34.5 yr, range 18–58) met all of the above criteria; thus, data from 20 participants

Group (language background)	N	Gender	Mean age (yr)
EGS trilinguals	5	4f, 1m	31.0
GES trilinguals	5	4f, 1m	46.6
EG bilinguals	6	2f, 4m	26.8
GE bilinguals	4	3f, 1m	35.0

Table 1: Demographic data on participants, by group. Group abbreviations: EGS = English-German-Spanish, GES = German-English-Spanish, EG = English-German, GE = German-English. Gender abbreviations: f = female, m = male.

were included in the analysis. These participants comprised four groups: L1 English-L2 German-L3 Spanish (EGS) trilinguals, L1 German-L2 English-L3 Spanish (GES) trilinguals, L1 English-L2 German (EG) bilinguals, and L1 German-L2 English (GE) bilinguals. All 20 participants in the final sample were living in the US at the time of their participation in the study; four reported spending time living abroad as well (3 in Spain, 1 in Argentina). Demographic data on these participants are summarized in Table 1. Note that the necessary exclusion of participants who did not meet the eligibility criteria listed above led to some variation in participant numbers as well as participant ages across groups.

3.2 Materials and Procedure

The study protocol consisted of three language tasks in each of the participant's languages: (1) a reading task, (2) a LexTALE task, and (3) a picture narration task (the focal task), in that order. To maximize the likelihood of every participant completing the study in its entirety, we opted to have participants complete all language blocks in a single session rather than in multiple sessions across different days. Therefore, in order to minimize incidental language co-activation across language blocks, we included a reading task as the first task in each block to encourage activation of the target language prior to the LexTALE and picture narration tasks within that block. Speech from the reading task was not subjected to analysis of rhythm on the basis of previous findings suggesting that reading-based tasks produce significantly different rhythm patterns than natural spontaneous speech (Arvaniti, 2012); speech subjected to analysis of rhythm instead came from picture narration. A picture narration task was used instead of an open-ended free speech task in order to keep the vocabulary used in each speech sample relatively consistent between participants.

Thus, in each language block, participants first completed a reading task, then a LexTALE task, and finally the picture narration task, with no time limit for any task. In the reading task, they read aloud a brief passage in the target language. All passages were retrieved from Lingua.com (2020) and were rated at a B1 level on the Common European Framework of Reference scale. In the LexTALE, participants completed a brief visual lexical decision task in the target language, which produced a score used as a measure of proficiency. The English and German versions of LexTALE were from Lemhöfer and Broersma (2012); the Spanish version was from Izura et al. (2014). In the picture narration task, participants were presented with a series

of four cartoons (each containing no text) and were asked to describe what they saw in each cartoon in as much detail as possible, as if they were speaking to a monolingual speaker of the target language who could not see the cartoon. A full list of references for the passages used in the reading task and a full list of references for the cartoons used in the picture narration task are available open-access via the Open Science Framework (OSF) at `https://osf.io/mxu5j/`.

Due to the COVID-19 pandemic, all data collection took place online via a survey administered on Qualtrics (2021) on the participant's personal electronic device. After providing informed consent for participation in the study, participants began audio-recording themselves using their phone's internal mic and native recording application. Each participant completed the three language tasks in the first designated language (i.e., the first language block), and then proceeded to the following language block(s). The order in which participants completed the language blocks (English, German, Spanish, as relevant) was counterbalanced to control for any extraneous effect of sequential language activation. After completing all language blocks, participants stopped the recording and then submitted the recording file to the researchers via the Qualtrics survey. The final part of the study protocol was a brief language background questionnaire (conducted in English on Qualtrics), which requested information about participants' perceived proficiency, frequency of use, and language dominance in each of their languages. This questionnaire is also available on OSF at the above address. The entire study protocol took about 30–45 minutes to complete depending on whether the participant was completing two or three language blocks.

3.3 Acoustic Analysis

The 50 audio recordings of the participants' speech from the picture narration task (10 trilinguals $\times$ 3 languages + 10 bilinguals $\times$ 2 languages) were analyzed using Praat (Boersma & Weenink, 2009). For each recording, a representative sample of approximately 1 minute of speech was identified for acoustic annotation; most often, this sample was from the beginning of the narration of the second cartoon, roughly 1–2 minutes into the recording. The speech samples were annotated by the first author in a TextGrid marking the durations of all consonantal and vocalic intervals in the speech stream; a detailed description of the annotation protocols is available at `https://osf.io/pvmea/`. On the basis of these durations, VarcoV values were calculated for each participant in each of their languages using the formula in (1).

$$(1) \qquad VarcoV = \frac{\text{standard deviation of vocalic interval durations}}{\text{mean vocalic interval duration}} \times 100$$

The full dataset, including both the acoustic data and participants' demographic and language background data, is available at `https://osf.io/pgbuj/`.

To check the reliability of the acoustic annotations that were the basis of the acoustic dataset, a subset of 5% of the recordings was randomly selected and reanalyzed by the second author, a trained phonetician with knowledge of Spanish, English, and German. This analysis showed a high degree of correspondence between the two sets of annotations, as reflected in the percentage of vocalic intervals

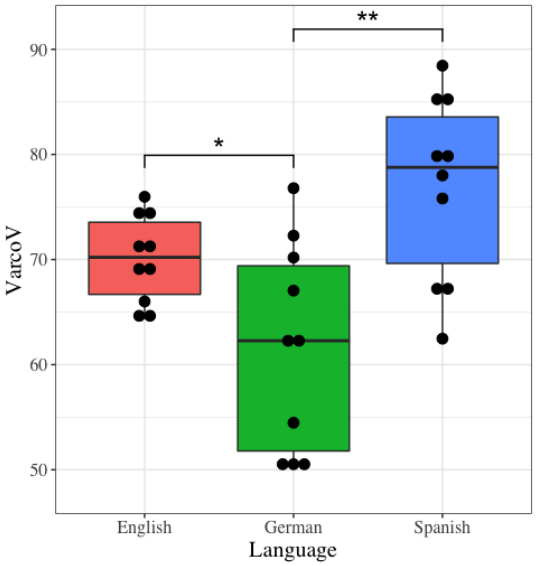

Figure 1: Boxplot of VarcoV values in trilinguals (including EGS and GES), by language. Dots represent individuals. Significance codes: * $p < 0.05$, ** $p < 0.05$.

that overlapped between the two sets: 88% for Spanish, 81% for English, and 99% for German. Furthermore, the durations of vocalic intervals in the second set of annotations were strongly correlated with the corresponding durations in the first set [Spanish: Pearson's $r = 0.925, t(83) = 22.150, p < 0.001$; English: Pearson's $r = 0.856, t(117) = 17.935, p < 0.001$; German: Pearson's $r = 0.905, t(76) = 18.518, p < 0.001$]. These results suggest that the vocalic interval duration data—and, by implication, the VarcoV values calculated from these data—are reliable.

4 Results

4.1 L3 Spanish Rhythm

The first step in our analysis was to determine whether the trilingual participants had developed an L3 rhythm system that was sufficiently different from their L1 and/or L2 systems to potentially trigger rCLI. To this end, the VarcoV values of the trilinguals were compared across languages (see Figure 1). Overall, the results suggested that the trilinguals had indeed developed an L3 Spanish rhythm system that was distinct from their L1 and L2 systems.

A two-way repeated-measures analysis of variance (ANOVA) was performed to examine the effects of the within-subjects factor LANGUAGE (English, German, Spanish) and the between-subjects factor ORDER OF ACQUISITION (i.e., group; EGS, GES) on VarcoV. The ANOVA indicated a significant main effect of LANGUAGE [$F(2, 16) = 11.26, p < 0.001$], but no main effect of ORDER OF ACQUISITION [$F(1, 8) = 0.21, p = 0.663$] and no interaction between the two factors [$F(2, 16) = 0.80, p = 0.468$]. Given the absence of a main effect or interaction

involving ORDER OF ACQUISITION, the data from EGS and GES trilinguals are combined in Figure 1. As shown in Figure 1, the LANGUAGE effect was due to a large disparity between Spanish and German (where Spanish showed higher VarcoV values), as well as a smaller disparity between English and German (where English showed higher VarcoV values). Post hoc comparisons indicated that the Spanish-German difference was significant [$t(9) = 5.43, p < 0.001$], as was the English-German difference [$t(9) = 2.35, p < 0.05$]; however, the Spanish-English difference was only marginal and not significant [$t(9) = 2.19, p = 0.056$].

It should be noted that the cross-language variation in VarcoV seen in Figure 1 was not in line with cross-language differences observed for native speakers of these languages. In particular, VarcoV values for Spanish were unexpectedly high. Recall from §2.2.2 that VarcoV values are generally expected to be lower in syllable-timed languages, such as Spanish, and higher in stress-timed languages, such as English and German; therefore, the finding of higher VarcoV values in Spanish compared to German (and, to a lesser extent, English) runs counter to this expectation. The potential implications of this finding are discussed in §5. Crucially, what this finding means for the investigation of rCLI in the present study is that potential rCLI from Spanish comes "from above" (i.e., via comparatively high values) on VarcoV, such that we can expect convergent rCLI in English or German to take the form of increased values on both metrics.

4.2 rCLI in English

Given that the trilinguals did in fact have a unique L3 Spanish rhythm system, the next step in our analysis was to see whether the L3 Spanish rhythm influenced the rhythm of English (= L1 for the EGS trilinguals; L2 for the GES trilinguals). This analysis involved two comparisons of English VarcoV values: one based on L3 Spanish knowledge (i.e., yes/trilinguals vs. no/bilinguals) and one based on order of acquisition (e.g., EGS vs. GES trilinguals). These comparisons are plotted in Figure 2.

A two-way ANOVA was performed to examine the effects of the between-subjects factors SPANISH KNOWLEDGE (no/bilingual, yes/trilingual) and ORDER OF ACQUISITION of English (L1, L2) on English VarcoV. The ANOVA showed a significant main effect of SPANISH KNOWLEDGE [$F(1, 16) = 15.10, p < 0.01$], but not of ORDER OF ACQUISITION [$F(1, 16) = 0.50, p = 0.489$]. Additionally, there was a significant SPANISH KNOWLEDGE $\times$ ORDER OF ACQUISITION interaction [$F(1, 16) = 5.11, p < 0.05$], which reflected a larger effect of Spanish knowledge—that is, a larger disparity between trilinguals and the respective bilingual control group—when English was the L1 (Figure 2). A post hoc Tukey's test revealed that the EGS trilinguals' VarcoV values were significantly higher than the EG bilinguals' [$p < 0.01$] and the GE bilinguals' [$p < 0.05$]; however, the GES trilinguals' VarcoV values were not significantly different from the GE or EG bilinguals' [p's > 0.05].

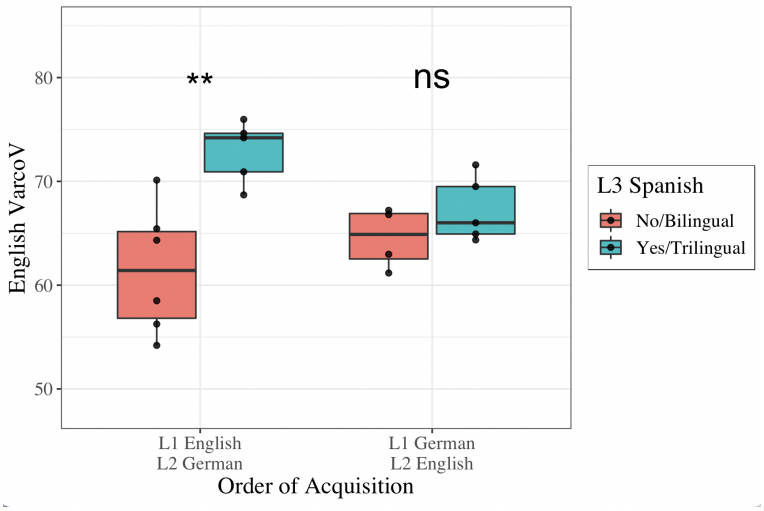

Figure 2: Boxplot of VarcoV values in English, by order of acquisition (L1, L2) and Spanish knowledge (no/bilingual, yes/trilingual). Dots represent individuals. Significance codes: ** $p < 0.01$, 'ns' $p > 0.05$.

4.3 rCLI in German

The final step in our analysis was to see whether trilinguals' L3 Spanish rhythm influenced the rhythm of German (= L2 for the EGS trilinguals; L1 for the GES trilinguals). Comparisons of German VarcoV values by Spanish knowledge and by order of acquisition of German are plotted in Figure 3.

In short, the results of this analysis showed no evidence of rCLI, in either L1 German or L2 German. A two-way ANOVA with between-subjects factors SPANISH KNOWLEDGE (no/bilingual, yes/trilingual) and ORDER OF ACQUISITION of German (L1, L2) showed no main effect of SPANISH KNOWLEDGE [$F(1, 16) = 0.66, p = 0.428$] or of ORDER OF ACQUISITION [$F(1, 16) = 0.12, p = 0.739$] and no interaction between these factors [$F(1, 16) < 0.01, p = 0.963$].

5 Discussion

This study tested two hypotheses concerning the role of order of acquisition and language similarity in predicting rCLI in multilingual speech rhythm. Focusing on the case of syllable-timed Spanish as L3 and stress-timed English and German as L1/L2, we found evidence of L3 Spanish exerting an assimilatory influence on the rhythm of English (the more typologically similar language to Spanish) but not of German, thus supporting hypothesis H2 concerning similarity. Crucially, however, this convergent rCLI in English was found only when English was the L1 (i.e., in EGS trilinguals), contradicting hypothesis H1 concerning order of acquisition. Recall that H1 (favoring rCLI in the L2) and H2 (favoring rCLI in English) had together predicted the strongest rCLI in L2 English (H3); however, counter to H3, our results revealed no significant rCLI in L2 English and, instead, rCLI only in L1 English. Therefore,

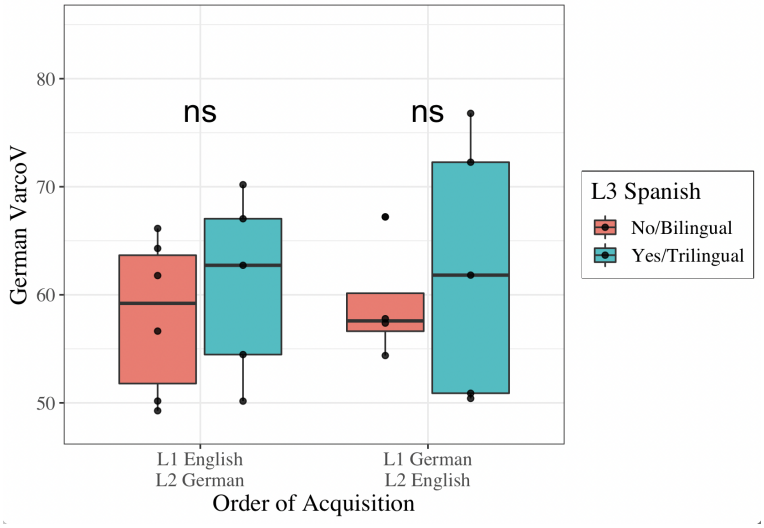

Figure 3: Boxplot of VarcoV values in German, by order of acquisition (L1, L2) and Spanish knowledge (no/bilingual, yes/trilingual). Dots represent individuals. Significance code: 'ns' $p > 0.05$.

while consistent with the view that order of acquisition and language similarity interact in shaping phonological CLI, these findings suggest a different interaction than the one assumed in H3, one in which L1 status, as opposed to L2 status, serves to enhance the effect of language similarity. Broadly speaking, this interaction is at odds with the PPH (Cabrelli Amaro & Rothman, 2010) but in line with studies showing a facilitative effect of L1 status on rCLI (Sypiańska, 2016; Liu et al., 2019).

Before discussing the results further, we would like to address the unexpected finding for L3 Spanish (see §4.1) in which Spanish showed VarcoV values that were higher than those of English and German, counter to the expectation of lower VarcoV values in syllable-timed languages. We believe that this finding may have arisen through the confluence of two factors: pCLI from stress-timed languages and cross-linguistic dissimilation. First, given that Spanish was a later-acquired language for the participants who spoke it, VarcoV values could generally be expected to be higher than in L1 Spanish speakers (White & Mattys, 2007), at least in part due to pCLI from the higher VarcoV values of a stress-timed L1 and/or L2. Second, if the rhythmic patterns of any of the trilinguals' languages (which may occupy a shared mental phonetic space; cf. Flege, 1995) were too similar, this could lead to dissimilation between two or more languages, resulting in the polarization of Spanish rhythm away from that of German and English. Of course, this does not in itself explain why Spanish would dissimilate in the direction of higher as opposed to lower VarcoV values, although it is possible that cycles of pCLI and rCLI over the course of L3 Spanish development eventually lead to a point where a trilingual's English and German fall below Spanish in terms of VarcoV values; from that point, dissimilation of Spanish would have to proceed in the direction of higher VarcoV values. Regardless of the reason for the higher VarcoV values in L3 Spanish, these higher values positioned the current study

to detect convergent rCLI in terms of increased VarcoV values in the L1/L2.

In fact, we did find convergent rCLI in the form of increased VarcoV values, but it was not related to order of acquisition in the manner predicted by H1, which merits an explanation. Recall that H1 was based on the logic of the PPH, which predicts that the L2 will be more "permeable" to phonological rCLI from the L3 than will the L1; therefore, our results, in which trilinguals' L2 consistently failed to show rCLI and the only evidence of rCLI occurred in (some) trilinguals' L1, contradicts the PPH. Why might Cabrelli Amaro and Rothman (2010) have found rCLI in the L2 whereas our results showed rCLI only in the L1? There are two possible, and not mutually exclusive, ways of reconciling these conflicting findings. First, these studies differed in terms of the central comparison made: Cabrelli Amaro and Rothman compared a bilingual repertoire acquired sequentially (L1, L2) to one acquired simultaneously (two L1s, i.e. $L1_a$ and $L1_\alpha$) whereas we compared two sequentially acquired repertoires evincing opposite orders of acquisition (L1 English-L2 German vs. L1 German-L2 English). Thus, it is possible that the L2 vs. $L1_\alpha$ contrast examined by Cabrelli Amaro and Rothman is qualitatively different from the L2 vs. sole L1 contrast examined in the current study. Perhaps, for example, acquiring multiple L1s simultaneously has the effect of enhancing the relative distinctiveness in neural representation that is associated with an early-acquired language, leading to greater L1 stability in the face of new language experience. Second, these studies differed in the phonological feature investigated: Cabrelli Amaro and Rothman investigated the specific feature of coda consonant production (see also Cabrelli Amaro, 2017, on vowel reduction), whereas we looked at the more global feature of speech rhythm. Thus, it is also possible that the disparity in the locus of rCLI observed across these two studies is related to the type of feature at issue. Perhaps, for example, the L1 is more permeable than the L2 to rCLI when it comes to higher-level features such as rhythm, speech posture, and articulatory setting. Further research is needed to understand how the locus and/or form of rCLI may depend on factors such as a multilingual's acquisition profile and properties of the linguistic feature being examined.

Crucially, the pattern of convergent rCLI found in this study was consistent with the predicted effect of typological similarity between languages, which leads us to propose the SIMILARITY CONVERGENCE HYPOTHESIS:

(2) **Similarity Convergence Hypothesis** (SCH): All other things being equal, the greater the typological similarity between an earlier-acquired language and a later-acquired language in the multilingual repertoire, the more likely it becomes for regressive cross-linguistic influence to occur at the phonological level, resulting in the earlier-acquired language converging with (i.e., becoming more similar to) the later-acquired language.

According to the SCH, the likelihood of rCLI from an L3 to an L1/L2 is directly related to similarity between languages, which means that rCLI should be more likely when the L1/L2 is more similar to the L3 as compared to when it is less similar. This is consistent with our findings from the English vs. German comparison: English was the typologically more similar language to Spanish (see §2.3) and therefore more likely to show rCLI from Spanish, and indeed rCLI was found in English but

not in German. As formulated in (2), the SCH is concerned specifically with rCLI resulting in cross-linguistic convergence because the directionality of the rCLI observed in this study was only convergent: compared to bilinguals' VarcoV values, trilinguals' VarcoV values for English were elevated in the direction of their higher VarcoV values for L3 Spanish, thus resulting in convergence toward the L3. As such, the SCH does not rule out the possibility that rCLI may result in divergence in other circumstances, such as with features that are not phonological or with multilinguals representing a different acquisition profile; however, for the case of rCLI at the phonological level in sequential multilinguals, the SCH predicts that cross-linguistic similarity will heighten the likelihood of rCLI, and that the rCLI will be convergent, leading to phonological features in the earlier-acquired language becoming more similar to those of the later-acquired language. Future work on rCLI in multilingualism may shed light on the conditions under which rCLI may result in divergence instead of convergence, as well as the range of possibilities for interaction between language similarity and order of acquisition effects.

One question that arises in regard to the SCH is whether the similarity that predicts rCLI is typological (structural) or psycho-typological. In other words, is the relevant similarity determined analytically on the basis of a systematic comparison of language structures by the linguist (or parser in the TPM), or is it perceived by the language user in a subconscious and subjective manner, which may or may not be based on structural comparisons? In (2), we have formulated the SCH to reference typological similarity, because typological similarity, determined using the process proposed in the TPM, was the basis for our original hypothesis H2. We did not collect data on the relative psycho-typological similarity between English and Spanish or between German and Spanish, so we are not in a position to say whether psycho-typological similarity aligns with the typological similarity among these languages. That is to say, the current findings cannot directly address the above question. Nevertheless, we remain open to the possibility that psycho-typological similarity may play an important role in rCLI, and we look forward to further research that may help tease apart the roles of typological similarity and psycho-typological similarity in predicting CLI in multilingualism.

6 Conclusion

The current study makes two contributions to the literature on CLI in multilingualism. First, we found evidence of a significant effect of typological similarity between languages on rCLI in speech rhythm, supporting the proposed Similarity Convergence Hypothesis. Second, we found an interaction between language similarity and order of acquisition in predicting rCLI, whereby rCLI arising from language similarity occurred in the L1 but not the L2. Together with previous results on both pCLI (for a recent summary, see Puig-Mayenco, González Alonso, and Rothman, 2018) and rCLI in multilingualism (e.g., Cabrelli Amaro & Rothman, 2010; Sypiańska, 2016; Liu et al., 2019), these findings contribute to a view of the multilingual repertoire as a complex, dynamic, and multi-directional network of relationships, where links between languages may occur at multiple levels of specificity, may be influenced by the

history of how languages were acquired, and may change over time as a result of a variety of factors, including but not limited to language similarity, age of acquisition, and language proficiency.

In closing, there are several directions for future work in this area, and here we mention four. First, perceptual research using methods such as accent rating and perceptual identification and discrimination will help round out the picture of our findings on rCLI in production. While this study demonstrated that L3 acquisition may affect multilinguals' production of speech rhythm in their L1/L2, it is not yet clear whether these effects are perceptible to listeners of the L1/L2; it is also unclear whether the speech perception of multilinguals may be influenced by rCLI in a similar manner. Second, although the current study found that rCLI may occur at a relatively high level of L3 proficiency ("intermediate" to "advanced"), L3 acquisition continues even beyond this level of proficiency, and future work examining rCLI using a longitudinal approach, such as that of Zhang et al. (this volume), will provide insight into how rCLI, and the cross-language links it reflects, may change over the course of multilingual development. Third, considering different language combinations and other acquisition profiles will shed further light on the interaction between language similarity and order of acquisition. For example, it is possible that the role of order of acquisition in rCLI may be different when the disparity between the L1 and L2 in terms of similarity to the L3 is even greater (e.g., L1/L2 English/Mandarin, L3 Spanish); by the same token, it is possible that the role of language similarity may be different when the previously-learned languages were acquired simultaneously rather than sequentially (i.e., two L1s, as opposed to L1/L2). The manifestation of rCLI in these scenarios remains an empirical question. Finally, future research examining, within the same study, multiple phonological features of different types (e.g., spectral, temporal) and at different levels of specificity (e.g., segmental, prosodic) will sharpen our understanding of the full scope of rCLI at the phonological level.

References

Abercrombie, D. (1967). *Elements of general phonetics*. Edinburgh, UK: Edinburgh University Press.

Ahn, S., Chang, C. B., DeKeyser, R., & Lee-Ellis, S. (2017). Age effects in first language attrition: Speech perception by Korean-English bilinguals. *Language Learning*, *67*(3), 694–733.

Anderson-Hsieh, J., Johnson, R., & Koehler, K. (1992). The relationship between native speaker judgments of nonnative pronunciation and deviance in segmentals, prosody, and syllable structure. *Language Learning*, *42*(4), 529–555.

Arvaniti, A. (2012). The usefulness of metrics in the quantification of speech rhythm. *Journal of Phonetics*, *40*(3), 351–373.

Bardel, C., & Falk, Y. (2007). The role of the second language in third language acquisition: The case of Germanic syntax. *Second Language Research*, *23*(4), 459–484.

Bardel, C., & Falk, Y. (2012). The L2 status factor and the declarative/procedural distinction. In J. Cabrelli Amaro, S. Flynn, & J. Rothman (Eds.), *Third language acquisition in adulthood* (pp. 61–78). Amsterdam: John Benjamins Publishing. doi: 10.1353/lan.2014.0011

Boersma, P., & Weenink, D. (2009). *Praat: Doing phonetics by computer.* (Version 5.1.13. Available from http://www.praat.org)

Brown, M. M. (2020). Grammatical gender acquisition in sequential trilinguals: Influence of a gendered L1 vs. L2. *Proceedings of the Linguistic Society of America*, *5*(1), 331–344.

Bylund, E. (2009). Effects of age of L2 acquisition on L1 event conceptualization patterns. *Bilingualism: Language and Cognition*, *12*(3), 305–322.

Cabrelli Amaro, J. (2017). Testing the Phonological Permeability Hypothesis: L3 phonological effects on L1 versus L2 systems. *International Journal of Bilingualism*, *21*(6), 698–717.

Cabrelli Amaro, J., & Rothman, J. (2010). On L3 acquisition and phonological permeability: A new test case for debates on the mental representation of nonnative phonological systems. *International Review of Applied Linguistics in Language Teaching*, *48*(2–3), 275–296.

Cabrelli Amaro, J., & Wrembel, M. (2016). Investigating the acquisition of phonology in a third language - A state of the science and an outlook for the future. *International Journal of Multilingualism*, *13*(4), 395–409.

Chan, I. L., & Chang, C. B. (2019). Perception of nonnative tonal contrasts by Mandarin-English and English-Mandarin sequential bilinguals. *Journal of the Acoustical Society of America*, *146*(2), 956–972.

Chang, C. B. (2010). *First language phonetic drift during second language acquisition* (Unpublished doctoral dissertation). University of California, Berkeley, Berkeley, CA.

Chang, C. B. (2019a). Language change and linguistic inquiry in a world of multicompetence: Sustained phonetic drift and its implications for behavioral linguistic research. *Journal of Phonetics*, *74*, 96–113.

Chang, C. B. (2019b). Phonetic drift. In M. S. Schmid & B. Köpke (Eds.), *The*

Oxford handbook of language attrition (pp. 191–203). Oxford, UK: Oxford University Press.

de Leeuw, E. (2019). Phonetic attrition. In M. S. Schmid & B. Köpke (Eds.), *The Oxford handbook of language attrition* (pp. 204–217). Oxford, UK: Oxford University Press.

de Leeuw, E., Mennen, I., & Scobbie, J. M. (2012). Singing a different tune in your native language: First language attrition of prosody. *International Journal of Bilingualism*, *16*(1), 101–116.

de Leeuw, E., Tusha, A., & Schmid, M. S. (2018). Individual phonological attrition in Albanian-English late bilinguals. *Bilingualism: Language and Cognition*, *21*(2), 278–295.

Dellwo, V. (2006). Rhythm and speech rate: A variation coefficient for ΔC. In P. Karnowski & I. Szigeti (Eds.), *Language and language processing: Proceedings of the 38th Linguistic Colloquium* (pp. 231–241). Frankfurt: Peter Lang.

Eibensteiner, L. (2019). Transfer in L3 acquisition: How does L2 aspectual knowledge in English influence the acquisition of perfective and imperfective aspect in L3 Spanish among German-speaking learners? *Dutch Journal of Applied Linguistics*, *8*(1), 67–83.

Falk, Y., & Bardel, C. (2010). The study of the role of the background languages in third language acquisition: The state of the art. *International Review of Applied Linguistics in Language Teaching*, *43*(2), 185–219.

Falk, Y., & Bardel, C. (2011). Object pronouns in German L3 syntax: Evidence for the L2 status factor. *Second Language Research*, *27*(1), 59–82.

Flege, J. E. (1980). Phonetic approximation in second language acquisition. *Language Learning*, *30*(1), 117–134.

Flege, J. E. (1987). The production of "new" and "similar" phones in a foreign language: Evidence for the effect of equivalence classification. *Journal of Phonetics*, *15*(1), 47–65.

Flege, J. E. (1995). Second language speech learning: Theory, findings, and problems. In W. Strange (Ed.), *Speech perception and linguistic experience: Issues in cross-language research* (pp. 229–273). Timonium, MD: York Press.

Flege, J. E., Birdsong, D. P., Bialystok, E., Mack, M., Sung, H., & Tsukada, K. (2006). Degree of foreign accent in English sentences produced by Korean children and adults. *Journal of Phonetics*, *34*(2), 153–175.

Flege, J. E., & Eefting, W. (1987). Cross-language switching in stop consonant perception and production by Dutch speakers of English. *Speech Communication*, *6*(3), 185–202.

Giancaspro, D., Halloran, B., & Iverson, M. (2015). Transfer at the initial stages of L3 Brazilian Portuguese: A look at three groups of English/Spanish bilinguals. *Bilingualism: Language and Cognition*, *18*(2), 191–207.

Grabe, E., & Low, E. L. (2002). Durational variability in speech and the Rhythm Class Hypothesis. In C. Gussenhoven & N. Warner (Eds.), *Laboratory phonology 7* (pp. 515–546). Berlin: Mouton de Gruyter.

Guilbault, C. P. G. (2002). *The acquisition of French rhythm by English second language learners* (Unpublished doctoral dissertation). University of Alberta,

Edmonton, Canada.

Guion, S. G. (2003). The vowel systems of Quichua-Spanish bilinguals: Age of acquisition effects on the mutual influence of the first and second languages. *Phonetica*, *60*(2), 98–128.

Gut, U. (2010). Cross-linguistic influence in L3 phonological acquisition. *International Journal of Multilingualism*, *7*(1), 19–38.

Han, Q., Tian, J., & Chen, H. (2022). L3 prosody: Cross-linguistic influence of prosodic features in Mandarin and English by Cantonese multilinguals. In M. M. Brown, S. Flynn, & É. Fernández-Berkes (Eds.), *L3 development after the initial state* (pp. xx–yy). Amsterdam: John Benjamins Publishing Company.

Izura, C., Cuetos, F., & Brysbaert, M. (2014). Lextale-Esp: A test to rapidly and efficiently assess the Spanish vocabulary size. *Psicológica*, *35*(1), 49–66.

Lemhöfer, K., & Broersma, M. (2012). Introducing LexTALE: A quick and valid Lexical Test for Advanced Learners of English. *Behavior Research Methods*, *44*(2), 325–343.

Lingua.com. (2020). *Lingua.com.* (Retrieved October 23, 2020)

Liu, Z., Gorba, C., & Cebrian, J. (2019). Effects of learning an additional language on VOT perception. In S. Calhoun, P. Escudero, M. Tabain, & P. Warren (Eds.), *Proceedings of the 19th International Congress of Phonetic Sciences* (pp. 260–264). Melbourne, Australia: Australasian Speech Science and Technology Association Inc.

Low, L. E., Grabe, E., & Nolan, F. (2000). Quantitative characterizations of speech rhythm: Syllable-timing in Singapore English. *Language and Speech*, *43*(4), 377–401.

Mayr, R., Sánchez, D., & Mennen, I. (2020). Does teaching your native language abroad increase L1 attrition of speech? the case of Spaniards in the United Kingdom. *Languages*, *5*(4), 41.

Mehler, J., Jusczyk, P., Lambertz, G., Halsted, N., Bertoncini, J., & Amiel-Tison, C. (1988). A precursor of language acquisition in young infants. *Cognition*, *29*(2), 143–178.

Mennen, I. (2004). Bi-directional interference in the intonation of Dutch speakers of Greek. *Journal of Phonetics*, *32*(4), 543–563.

Minai, U., Gustafson, K., Fiorentino, R., Jongman, A., & Sereno, J. (2017). Fetal rhythm-based language discrimination: A biomagnetometry study. *NeuroReport*, *28*(10), 561–564.

Nazzi, T., Bertoncini, J., & Mehler, J. (1998). Language discrimination by newborns: Toward an understanding of the role of rhythm. *Journal of Experimental Psychology: Human Perception and Performance*, *24*(3), 756–766.

Nespor, M., Shukla, M., & Mehler, J. (2011). Stress-timed *vs.* syllable-timed languages. In M. van Oostendorp, C. J. Ewen, E. Hume, & K. Rice (Eds.), *The Blackwell companion to phonology* (Vol. II. Suprasegmental and Prosodic Phonology, chap. 48). Chichester, UK: Wiley-Blackwell.

Olson, D. J. (2020). Short-term sources of cross-linguistic phonetic influence: Examining the role of linguistic environment. *Languages*, *5*(4), 43.

Ordin, M., & Polyanskaya, L. (2015a). Acquisition of speech rhythm in a second

language by learners with rhythmically different native languages. *Journal of the Acoustical Society of America*, *138*(2), 533–544.

Ordin, M., & Polyanskaya, L. (2015b). Perception of speech rhythm in second language: The case of rhythmically similar L1 and L2. *Frontiers in Psychology*, *6*, 316.

Polyanskaya, L., & Ordin, M. (2015). Acquisition of speech rhythm in first language. *Journal of the Acoustical Society of America*, *138*(3), EL199–EL204.

Puig-Mayenco, E., González Alonso, J., & Rothman, J. (2018). A systematic review of transfer studies in third language acquisition. *Second Language Research*, *36*(1), 31–64.

Qualtrics. (2021). *Qualtrics research suite.* (Provo, Utah, USA. Available from http://www.qualtrics.com)

Ramus, F., Nespor, M., & Mehler, J. (1999). Correlates of linguistic rhythm in the speech signal. *Cognition*, *73*(3), 265–292.

Rothman, J. (2010). On the typological economy of syntactic transfer: Word order and relative clause high/low attachment preference in L3 Brazilian Portuguese. *International Review of Applied Linguistics in Language Teaching*, *48*(2–3), 245–273.

Rothman, J. (2011). L3 syntactic transfer selectivity and typological determinacy: The Typological Primacy Model. *Second Language Research*, *27*(1), 107–127.

Rothman, J. (2013). Cognitive economy, non-redundancy and typological primacy in L3 acquisition: Evidence from initial stages of L3 Romance. In S. Baauw, F. Dirjkoningen, & M. Pinto (Eds.), *Romance languages and linguistic theory* (pp. 217–247). Amsterdam: John Benjamins Publishing.

Rothman, J. (2015). Linguistic and cognitive motivations for the Typological Primacy Model (TPM) of third language (L3) transfer: Timing of acquisition and proficiency considered. *Bilingualism: Language and Cognition*, *18*(2), 179–190.

Rothman, J., & Cabrelli Amaro, J. (2010). What variables condition syntactic transfer? A look at the L3 initial state. *Second Language Research*, *26*(2), 189–218.

Schepens, J., Dijkstra, T., & Grootjen, F. (2012). Distributions of cognates in Europe as based on Levenshtein distance. *Bilingualism: Language and Cognition*, *15*(1), 157–166.

Schepens, J., Dijkstra, T., Grootjen, F., & van Heuven, W. (2013). Cross-language distributions of high frequency and phonetically similar cognates. *PLoS ONE*, *8*(5), e63006.

Schmid, M., & Köpke, B. (2017). The relevance of first language attrition to theories of bilingual development. *Linguistic Approaches to Bilingualism*, *7*(6), 637–667.

Schmidt, E., & Post, B. (2015). The development of prosodic features and their contribution to rhythm production in simultaneous bilinguals. *Language and Speech*, *58*(1), 24–47.

Sypiańska, J. (2016). Multilingual acquisition of vowels in L1 Polish, L2 Danish and L3 English. *International Journal of Multilingualism*, *13*(4), 476–495.

Ulbrich, C. (2012). German pitches in English: Production and perception of cross-

varietal differences in L2. *Bilingualism: Language and Cognition*, *16*(2), 397–419.

Ulbrich, C. (2014). Can L2-English influence L1-German? The case of post-vocalic /r/. *Journal of Phonetics*, *45*, 26–42.

Westergaard, M., Mitrofanova, N., Mykhaylyk, R., & Rodina, Y. (2017). Crosslinguistic influence in the acquisition of a third language: The Linguistic Proximity Model. *International Journal of Bilingualism*, *21*(6), 666–682.

White, L., & Mattys, S. (2007). Calibrating rhythm: First language and second language studies. *Journal of Phonetics*, *35*(4), 501–522.

Willems, N. (1982). *English intonation from a Dutch point of view*. Dordrecht: Foris Publications.

Zhang, L., Morales-Front, A., & Sanz, C. (2022). Dynamics in cross-linguistic influence - Evidence from VOT development of Mandarin-English bilingual learners of L3 Spanish. In M. M. Brown, S. Flynn, & É. Fernández-Berkes (Eds.), *L3 development after the initial state* (pp. xx–yy). Amsterdam: John Benjamins Publishing Company.