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Production of Vowel Reduction by Mexican Learners of English as L2 and Russian as L3

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Abstract

In this study, we examined to what extent cross-linguistic influence is observed in the production of unstressed vowels in Mexican learners of L2 English and L3 Russian. Phonological spectral vowel reduction is a widespread process present in both English and Russian, but not in Spanish. In total, 18 Mexican learners, six American speakers, five Russian speakers and six Mexican speakers performed a delayed word repetition task and a sentence completion task. Euclidean distances and temporal values were measured to assess vowel reduction in 1,192 tokens. Mexican learners showed hybrid values of vowel reduction in both foreign languages: while they tended to use quality cues in the case of the L2, they relied on duration cues in the case of the L3. Our results do not show any direct evidence of cross-linguistic influence of temporal values or vowel quality from the L1 or the L2 on the L3. We examine these findings in light of similar studies and current L3 acquisition models.

Key words: multilingualism, vowel reduction, third language acquisition, crosslinguistic influence

Résumé

Dans cette étude, nous avons examiné dans quelle mesure est observable l'influence interlinguistique dans la production de voyelles non accentuées chez les apprenants mexicains de l'anglais L2 et du russe L3. La réduction spectrale phonologique des voyelles est un processus répandu et présent à la fois en anglais et en russe, mais pas en espagnol. Au total, 18 apprenants

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mexicains, six locuteurs américains, cinq locuteurs russes et six locuteurs mexicains ont effectué une tâche de répétition différée de mots et une tâche de complétion de phrases. Les distances euclidiennes et les valeurs temporelles ont été mesurées pour évaluer la réduction des voyelles dans 1 192 instances. Les apprenants mexicains ont montré des valeurs hybrides de réduction des voyelles dans les deux langues étrangères : alors qu'ils avaient tendance à utiliser des indices de qualité dans le cas de la L2, ils se sont appuyés sur des indices de durée dans le cas de la L3. Nos résultats n'apportent aucune preuve directe d'une influence interlinguistique des valeurs temporelles ou de la qualité des voyelles de la L1 ou de la L2 sur la L3. Nous examinons ces résultats à la lumière d'études similaires et des modèles actuels d'acquisition de la L3.

Mots clés: multilinguisme, réduction des voyelles, acquisition d'une langue tierce, influence interlinguistique

1. Introduction

Many scholars point out that multilingualism has become completely natural in the Western world: numerous people migrating to foreign countries are obliged to learn one or more languages of their host communities in order to be able to communicate effectively in professional and personal contexts (De Angelis 2007, Day and Wagner 2007, Dewaele 2007). In Mexico, foreign language acquisition is increasingly important as well. For example, while English is usually taught as a foreign language beginning at the primary-school level, a large number of undergraduate students start learning additional foreign languages (henceforth referred to as L3) like French, Italian, Russian, Chinese, and so on, at university.[1]

According to the approach adopted in this article, an L3 learner is any learner who has previously acquired a second language (henceforth referred to as L2). For example, a Mexican learner of Russian who has already acquired English is an L3 learner. At the same time, in addition to the languages mentioned above, this learner may have acquired some other language as well (e.g., German, Arabic, Nahuatl, etc.), but, according to the approach employed in this study, all languages which have been acquired after the L2 are considered L3s. De Angelis (2007) and Cabrelli Amaro (2012) adopt the same point of view regarding the definition of an L3. According to the former, this category of students must be regarded as multilingual learners, and their oral skills must be analysed separately from L2 learners.

In this respect, studies on second language acquisition have shown that communicative and linguistic skills may differ considerably between L2 and L3 learners (Cenoz, Hufeisen, and Jessner 2001). In contrast to L2 acquisition, where the influence of a speaker's first language (L1) presents one of the main factors constraining interlanguage phonologies (Gass and Selinker 2001, Flege 1995), research on L3 phonology is often conducted to determine to what extent both an L1 and non-native languages acquired

[1] Abbreviations used: CLI: cross-linguistic influence; ED: Euclidian distance; L2SFM: L2Status Factor Model; LPM: Linguistic Proximity Model; NLM: Native Language Magnet Model; OPM: Ontogeny Phylogeny Model; SLM: Speech Learning Model; VOT: voice onset time.

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afterwards are potential sources of cross-linguistic influence (henceforth referred to as CLI) (Wrembel 2015). Studies on L3 phonology have shown that multilingual learners may restructure their L3 phonetic space owing to the influence of both their native language and additional languages (L2 and L3s). This kind of CLI has been found in the production of VOT values (Wrembel 2015), segmentals (Pyun 2005), rhythmic patterns and vowel reduction (Gut 2010), as well as many other phonetic phenomena (see Marx and Mehlhorn 2010, for more details).

Several reasons may be advanced to explain the benefits of acquiring an L3. Firstly, L3 learners have greater knowledge of language learning strategies and more extensive experience in this process in comparison with L2 learners: whereas the latter are merely acquiring their L2, the former have already acquired at least one foreign language and are learning another one, which leads to an entirely different learning experience (De Angelis 2007, Dewaele 2007, Cabrelli Amaro and Wrembel 2016). Secondly, learning an L3 may simultaneously activate phonological systems of all languages in the mind of the speaker, so that previous L2 phonological knowledge may enhance the acquisition of similar sound patterns in an L3 (Marx and Melhorn 2010). Thirdly, this category of learners may enjoy enhanced perceptual sensitivity when acquiring new foreign languages (Enomoto 1994, Onishi 2016). Fourthly, some authors claim that multilingual speakers tend to develop better phonological awareness in comparison with L2 learners (Williams and Hammarberg 1998, Gut 2010). For these reasons, L3 acquisition has recently been recognised as a distinct process and, as a result, should be studied separately (De Angelis 2007, Marx and Melhorn 2010, Cabrelli Amaro and Wrembel 2016).

In this study, we focus on the acquisition of vowel reduction by multilingual learners. Numerous studies have examined the production and the perception of this phenomenon by L2 learners (Gómez Lacabex et al. 2005, Ronquest 2013, Diettes 2014, Byers and Yavaș 2017, among others). Nonetheless, even though more and more studies are being published in the field of L3 phonological acquisition, the number of studies focusing on L3 vowel reduction is still limited. In this exploratory investigation, we examine to what extent learners who have acquired L2 vowel reduction benefit from this when acquiring a similar phenomenon in an L3. This, in turn, might enable us to obtain a better understanding of the CLI of the L1 and the L2 on the phonology of the L3 in the case of three typologically distant languages. We analyse the acoustic patterns of unstressed vowels produced by Mexican Spanish learners in L2 English and L3 Russian. While vowel reduction is a phonological process in both English (Ladefoged 1999, Roach 2009, Ladefoged and Johnson 2011) and Russian (Avanesov 1956, Knyazev and Pozharitskaya 2005, Iosad 2012), it is merely phonetic in Spanish (Quilis and Fernández 2003, Martín Butragueño 2014).

2. Vowel reduction

In Section 2 we define vowel reduction, describe its manifestations in various languages and present the past-to-present literature on the phonological acquisition of L3. Afterwards, we present several models of L3 acquisition and make some predictions about the expected results of this study.

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2.1. Vowel reduction in stress-timed and syllable-timed languages

Phonological vowel reduction is a phenomenon in which unstressed vowels are produced with less articulatory effort, so that their formant frequencies become more schwa-like (Harrington 2010). This is an obligatory process in languages which are considered predominantly stress-timed such as English (Ladefoged 1999, Roach 2009, Ladefoged and Johnson 2011), German (Kohler 1999) or Russian (Avanesov 1956, Knyazev and Pozharitskaya 2005, Iosad 2012). In these languages, vowel reduction allows the difference between stressed and unstressed syllables to be maximised (Lindblom 1990). For instance, in most varieties of English, unstressed vowels weaken due to phonological, metrical and morphological factors. This phenomenon can be observed in the alternation between /eɪ/ and /ə/ in *Canadian* and *Canada*. Contrary to stress-timed languages, vowel reduction is not regarded as phonological in syllable-timed languages like Spanish (Quilis and Fernández 2003, Martín Butragueño 2014), Italian (Bertinetto and Loporcaro 2005) or French (Fougeron and Smith 1999): the phonetic realisation of unstressed vowels is always very similar to those of their stressed counterparts, even if these vowels display some kind of reduction in both temporal and spectral properties. In Spanish, for example, the vowel /o/ is always produced as [o] in the words *ecólogo* 'ecologist' and *ecológico* 'ecological' regardless of morphological changes.

Unlike phonological vowel reduction, its phonetic counterpart commonly refers to a vowel undershoot due to prosodic, temporal and speech rate factors (Harrington 2010). Phonetic vowel reduction is considered to be a result of hypo-articulation, which is supposed to apply to all vowels (stressed vowels included). In the latter case, spectral and temporal vowel reduction may be observed in syllable-timed languages like Spanish (Quilis and Fernández 2003, Martín Butragueño 2014) or French (Gendrot and Adda-Decker 2016). Nevertheless, these languages do not centralise unstressed vowels into a schwa-like vowel as English or Russian do (Fletcher 2010).

2.2. Vowel reduction in Mexican learners' L1, L2, and L3

As was mentioned earlier, phonological vowel reduction does not exist in Spanish (Hualde 2013). Yet, phonetic vowel reduction affecting all vowels can be observed in certain contexts, for instance, due to a fast articulation rate or to certain particularities of Mexican Spanish such as vowel devoicing (Delforge 2008). In contrast, vowel reduction is phonological in English. Most commonly, unstressed vowels are articulated as a schwa, /ə/, and sometimes as /ɪ/ (Ladefoged and Johnson 2011), depending on the position of the vowel in a word, the word's historical development, and sociological factors, among others. Furthermore, in Standard American Newscaster English (our L2 target dialect), schwas may become rhotacised in certain contexts, for instance at the end of the word: 'worker' /wɜːrkɚ/. As far as Russian is concerned, there are two types of phonological vowel reduction: moderate (in pretonic contexts) and radical reduction (in other unstressed contexts) (Avanesov 1956, Crosswhite 2000, Knyazev and Pozharitskaya 2005, Iosad 2012). For example, in *bali* (балы) /baˈli/ 'dancing parties' the pretonic vowel is slightly centralised: [bɐˈɫɨ]. An example of radical reduction is observed in the last syllable of the word *tochka*

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(точка) /ˈtot͡ʃka/ ‘point’: [ˈtot͡ʃkə]. As has been shown here, the vowel /a/, which occupies the pretonic and unstressed position in the words given above, was reduced to [ɐ] in *bali* and [ə] in *tochka*. Note that in all the aforementioned languages, lexical stress lengthens vowels. However, there is a fundamental difference between these languages: while unstressed vowels occupy the centre of the vowel space in English and Russian, they tend to be peripheral in Mexican Spanish (Hualde 2013, Santiago and Mairano 2019).

2.3. Previous studies of phonological acquisition in L3 learners

Research into L3 phonology is relatively recent. Frequently, the main objective of L3 research is to examine the effects of previously acquired languages (usually an L1 and an L2) on the learning of an L3 (Cabrelli Amaro and Wrembel 2016). L3 phonological studies analyse the complex patterns of CLI between an L1, an L2 and an L3, in addition to linguistic and extralinguistic factors (Cabrelli Amaro and Wrembel 2016).

Nonetheless, most studies on vowel reduction have been carried out in the field of L2 acquisition. They suggest that L2 learners find it extremely difficult to produce vowel spectral centralisations in a native speaker fashion (see Flege and Bohn 1989, and Diettes 2014, for L2 English by Spanish speakers; Gut 2003, for L2 German by French, Romanian and Italian learners; Sönning 2014, for L2 English by German learners). In regard to Spanish-speaking learners of L2 English, similarly, it has been demonstrated that these learners experience considerable difficulty in acquiring vowel reduction (Diettes 2014, Gómez Lacabex et al. 2005). Nevertheless, other studies (e.g., Byers and Yavaș 2017) point out that late Spanish-speaking learners are quite capable of acquiring this phenomenon, even though the phonetic patterns of L2 unstressed vowels may not necessarily coincide completely with those of native speakers.

As far as we know, only one author has addressed the question of the multilingual acquisition of L3 vowel reduction. Gut (2010) analysed temporal patterns of unstressed vowels in four multilingual learners of L2 English and L3 German from different linguistic backgrounds. The author did not find any evidence of a stress-timed linguistic background enhancing the acquisition of vowel reduction in an L2 or an L3. In fact, she argued that an L1 must contain a prominent vowel reduction so that it may be successfully transferred to an L2 or an L3. Hence, Gut did not obtain any evidence regarding the transfer of vowel reduction from the L2 to the L3. However, it is important to note that these results come from only four participants, from different linguistic backgrounds. Additionally, Gut’s investigation did not analyse the formant structure of reduced vowels.

It is necessary to highlight that L3 phonological acquisition research is still in its infancy; most relevant studies have been carried out in the field of L3 syntactic acquisition (Flynn et al. 2004, Bardel and Falk 2007, Falk and Bardel 2010, Rothman 2011, Falk et al. 2015, Westergaard et al. 2017). Fortunately, an increasing number of studies of L3 phonology are published every year. For example, Enomoto (1994) and Onishi (2016) analysed the perception of phonological contrasts in L3 Japanese, and both reached the conclusion that the general experience of learning several foreign languages may give an advantage to multilingual learners.

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Wrembel (2010) worked on how the accent of Polish learners with L2 German and L3 English was perceived, and discovered that lower level students tended to rely more on their second language and were mostly perceived as having a German as L1 by native speakers of English, while students with a more advanced command of the language were usually recognized as Polish L1 speakers. In another study, Wrembel (2015) analysed the production of Voice Onset Time values in L2 English and L3 French by German learners. She discovered no statistical difference between L1 German and L2 English values, while L3 French VOT was reported to be intermediate between the target values in this language and those in German and English. Kopečková et al. (2016) studied the interactions between three phonological systems: German, English, and Polish, in different groups of learners (heritage speakers of Polish vs. L3 learners of Polish). All the participants carried out a delayed repetition task in all of their languages. Even though the results displayed a high degree of variability, the authors showed the interconnectedness of all the systems and the influence of the heritage language on other languages.

As has been demonstrated, all of these studies show an extremely complex picture of CLI between the L1, the L2, and the L3. The principal findings of these studies indicate that (i) multilingual learners (L3) tend to perform better that their L2 counterparts; (ii) all the phonological systems developed by an L3 learner are in constant interaction with one another.

2.4. The acquisition of vowel reduction in multilingual learners: Predictions based on two models

Despite the fact that the acquisition of vowel reduction in multilingual learners has not been fully addressed in the literature, some hypotheses may be proposed in light of the various L3 acquisition models. In this study, we will employ two models: the Linguistic Proximity Model (LPM) (Westergaard et al. 2017) and the L2 Status Factor Model (L2SFM) (Bardel and Falk 2007, Falk and Bardel 2011). According to the first model, both facilitative and non-facilitative CLI may occur in the L3 on a property-by-property basis. These processes are triggered when the L3 shows structural similarities with one (or both) of the languages in the learner's linguistic repertoire. Consequently, according to the LPM, Mexican learners of L2 English and L3 Russian are highly likely to rely on their L2 when acquiring vowel reduction in their L3, because this process is phonological in both their L2 and their L3.

As far as the L2SFM is concerned, learners are expected to rely on their L2 when acquiring an L3 since the processes of acquisition of an L2 and an L3 are cognitively similar, which, in turn, leads to a major level of activation of foreign languages in subsequent language acquisition. Therefore, according to the tenets of this model, Mexican learners of L3 Russian will transfer vowel production from L2 English to L3 Russian.

Thus, both theories expect the Mexican learner of L2 English and L3 Russian to transfer vowel reduction from one foreign language to another. Even though the

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explanations for this phenomenon differ, the overall conclusions of both theories point in the same direction.[2]

However, despite the predictions of these models, it must be pointed out that it is very common to find evidence of the combined influence of various sources (both L1 and L2) on the L3. The findings of several investigations support this tendency: Wrembel (2015), Lloyd-Smith et al. (2017), and Kopečková et al. (2016). Thus, in spite of the predictions provided by the theories described above, it is possible that the values of the reduced vowels of Mexican learners might demonstrate the features of both L1 Spanish and L2 English.

2.5. Research questions and predictions

In light of the previous studies and the questions relating to the roles of the L1 and the L2 in L3 acquisition, our research questions are the following:

RQ1. To what extent are Mexican learners of English as an L2 and Russian as an L3 capable of producing vowel reduction in these languages when performing two types of tasks (delayed repetition task vs. sentence completion task)?

RQ2. Do Mexican learners of Russian as an L3 who have already acquired L2 English benefit from this knowledge, in terms of vowel reduction? In other words, to what extent will the L2 exert CLI on the L3?

RQ3. What kind of CLI will be observed between the L1, L2, and L3 and how will it be interpreted in light of current L3 phonological acquisition studies?

Firstly, according to the studies discussed in section 2.3 (Gómez Lacabex et al. 2005, Diettes 2014), vowel reduction is extremely challenging for Spanish speaking learners. Nevertheless, since most of the Mexican learners had an advanced command of English – a language with phonological vowel reduction (see 3.1.) – and a multilingual background, we predict they may be fully capable of producing unstressed vowels with at least a moderate amount of vowel reduction, uncharacteristic of Spanish, in both their L2 (see Byers and Yavaş 2017) and their L3, in both tasks. We did not expect reduced vowels to be very close to the values of native speakers, but we predicted them to be somewhat different from the values observed in L1 Spanish. Secondly, we predicted that Mexican learners of L3 Russian would rely mostly on their L2 English during the acquisition of vowel reduction, even though the influence of the L1 would still be present to some extent. Thus, we expected to obtain mixed values in Mexican learners' L3. These results would be in line with most studies on L3 acquisition (Wrembel 2015, Lloyd-Smith et al. 2017, and Kopečková et al. 2016).

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[2]Please note that both these theories are usually directed at L3 syntactic acquisition (e.g., see Falk and Bardel 2011, Westergaard et al. 2017). Having analysed various theories of L2 and L3 phonological acquisition (e.g., the SLM by Flege (1995, 2005), the OPM by Major (2001), the NLM by Iverson and Kuhl (1995), etc.), we arrived at the conclusion that these theories were not well suited for the present research. Either they made no explicit predictions about the acquisition of L3 phonology, or their strong versions have been refuted by a considerable number of studies. It was decided to use both the LPM and the L2SFM despite their limitations.

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3. METHODS

In section 3 we describe the participants' profile and linguistic background. We also explain the stimulus selection process, give a description of the tasks employed in this study, and clarify what acoustic metrics were used to analyse the stimuli.

3.1. Participants

The data consist of oral productions by 18 Mexican Spanish learners of both L2 English and L3 Russian (experimental group), six American English speakers, five Russian speakers and six Mexican Spanish speakers (control groups). The learners (10 males and eight females) were attending L2 English and L3 Russian (henceforth L2Eng and L3Rus respectively) courses at the National Autonomous University of Mexico (UNAM) at the time of the experiment. All the learners were born in monolingual Spanish-speaking households. All of them were pursuing Bachelor's/Master's degree studies in different domains (Mathematics, Administration, Philology, etc.). Their ages ranged from 21 to 39 years (*mean* = 26.11, *SD* = 4.84).

As we pointed out in section 2.3, Spanish-speaking students experience great difficulty in acquiring vowel reduction in L2Eng. For this reason, we decided to reduce the scope of this investigation to intermediate and advanced learners of English (B1 according to the Common European Framework of Reference for languages (CEFR), 350–400 hours of guided study, minimum), assuming that at this level of language command, students will be more likely to have begun the acquisition of vowel reduction, owing to a longer exposure to the target language. Concerning their skills in L3Rus, the learners' command of the language was required to be at least at the beginner-intermediate level (A2 according to CEFR, 180–200 hours of guided study, minimum).

The control groups were all tested in Mexico. The Mexican Spanish control group (L1Spa) consisted of three males and three females. They were brought up in monolingual Spanish-speaking households. Their ages ranged from 26 to 37 years (*mean* = 30.5, *SD* = 4.03). All of them were pursuing their studies, either postgraduate degree programmes or specialised courses, at the UNAM. The Russian-speaking control group (L1Rus) was composed of five native Russian speakers (three males and two females). Their ages ranged from 29 to 59 years (*mean* = 41.6, *SD* = 11.15). Regarding their occupation, three were musicians and two researchers. They were all born in Moscow. As for the English-speaking control group (L1Eng), six native speakers of American English (five males and one female) participated in the study. Their ages ranged from 21 to 59 years (*mean* = 29.33, *SD* = 13.52). Concerning their professional development, three participants were practising specialists, two were university students and one, a researcher. All of them were raised in monolingual households in the USA. None of the participants from the experimental or control groups were visually or hearing impaired.

3.2. Materials

We created a list of stimuli in English, Russian and Spanish consisting of 36 lexical items (nouns only) composed predominantly of two and three syllables. In addition to

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the 36 target words, 54 distractors were added to the list, resulting in a total of 90 words used in the experiment. Lexical items had the following features (see Appendix: *Supplementary Materials* for the complete list):

1. In Mexican Spanish, 12 words contained the phonemes /e/, /a/ and /o/ in both stressed and unstressed positions (2 words × 2 phonemes × 2 prosodic conditions). These phonemes are represented by the letters *e*, *a* and *o*. For instance, *elenco* [e.ˈleŋ.ko] ‘cast’ vs. *tesoro* [te.ˈso.ɾo] ‘treasure’, *lagarto* [la.ˈɣ̞aɾ.to] ‘lizard’ vs. *panfleto* [paɱ.ˈfle.to] ‘pamphlet’, and mono [ˈmo.no] ‘monkey’ vs. *polaco* [po.ˈla.ko] ‘Polish’.
2. In English, 12 words had the phonemes /ɛ/, /ɑː/, /ɔː/ and schwa /ə/, which tend be represented by the letters *e*, *a* and *o*. We used words in their Standard American spelling owing to the fact that it is the norm with which Mexican students are most familiar. Thus, we used six words with /ɛ/, /ɑː/, /ɔː/ in stressed position and six words with /ə/ in unstressed position). In the case of stressed vowels, the phonemes /ɛ/, /ɑː/ and /ɔː/ were analysed in words like *shelter, farmer* and *hornet*. As for schwa /ə/, three cases were examined: we used contexts where this vowel corresponded to the letters *e* (*leather*), *a* (*sugar*) and *o* (*manor*).
3. In Russian, 12 words contained the phonemes /e/, /a/ and /o/ and their reduced counterpart [ə]. These vowels are represented by the letters э, *a* and *o* in this language. Similarly, to the L2Eng data, we employed six words with /e/, /a/, and /o/ in stressed position and six words with [ə] in unstressed position. Concerning full vowels, the phonemes /e/, /a/, and /o/ were examined in words like *мэрия* [ˈmeɾʲja] ‘city hall’, *камень* [ˈkamʲɪ̈nʲ] ‘rock’ and *природа* [pɾʲɪˈrodə] ‘nature’. Regarding the reduced vowel [ə], we focused on the following cases: contexts when the vowel corresponded to the letter э (*экипáж* [əkʲi ˈpaʃ] ‘crew’), the letter *a* (побéда [pɐˈbʲɛdə] ‘victory’) and the letter *o* (ребё́нок [ɾʲɪ ˈbʲonək] ‘child’). Note that we did not analyse vowel reductions in pretonic contexts, focusing on unstressed positions only. We also avoided contexts leading to palatalisation and, as a result, changes in vowel reduction patterns: for example in *мёд* [mʲot] ‘honey n.’ vs. *медовый* [mʲɪˈdovij] ‘honey adj.’.

The choice of these items was based on the following criteria. We avoided the use of cognates between L1, L2, and L3 in order to prevent potential facilitative CLI from the L1 or a mere transfer of similar-looking words from one language to another (Amengual 2012). We thus selected primarily words of Germanic origin in English and words of Slavic (and in some cases of French) origin in Russian so that there were no direct cognates between Spanish and the target languages. In order to do so, most of the lexical items were chosen from the words located between word 300 and 600 in *Russian Learners' Dictionary* (Brown 1996), *A Frequency Dictionary of Contemporary American English* (Davies and Gardner 2010) and *A Frequency Dictionary of Spanish* (Davies and Hayward Davies 2018) as we sought to avoid lesser-known lexical items and the mere memorisation of the most common words. Furthermore, we selected words whose lexical content was easy to illustrate with images and would not represent a difficulty for learners, especially in L3 Russian.

These criteria resulted in some methodological issues. Firstly, it was extremely difficult to control the position of the stressed syllable in the word across all the languages. In both Spanish and English, stressed vowels were all in the penultimate

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syllables of words, whereas in Russian, stressed vowels appeared in different word-internal positions. Concerning unstressed vowels in Spanish, all of them were in the pretonic position, whereas this was not the case in English and Russian. Secondly, syllable structure as well as the consonants surrounding the target vowels were not controlled for between languages, nor within the same languages. These uncontrolled-for factors may have had an impact on both temporal values and vowel quality due to coarticulation effects, especially in the case of English: unstressed vowels were followed by the consonant /r/, potentially leading to the production of rhotacised vowels.

Nonetheless, observing stricter criteria across three typologically distinct languages would have immensely limited the choice of appropriate stimuli for learners who would have had to produce the words they had never used in their language courses. We thus decided to select words that learners produce in natural oral classroom interactions. In addition, in order to minimise the undesirable effects mentioned above, we analysed vowel centralisation by examining Euclidean distance (henceforth referred to as ED) and not by analysing formant structure of F1 and F2 values separately (see section 3.5). We also tried to minimise coarticulation effects by extracting formant values at the mid-point of vowels. Finally, L1/L2 English vowels produced with extreme rhotacisation (no visual evidence of vocalic formant transitions in unstressed vowels) were excluded from the analysis. These methodological issues were taken into account in our results and will be addressed in the discussion of the limitations of our results in the conclusion.

3.3. Tasks

The aforementioned stimuli were used in two different tasks: a word delayed repetition and a sentence completion task. In the first task, participants were asked to produce target vowels without written input. It allowed us to avoid: (i) errors in L2/L3 pronunciation caused by a non-facilitative transfer of grapheme-phoneme correspondence from the L1 (Bassetti 2017) and (ii) a mere phonetic imitation resulting in overperformance in terms of L2/L3 pronunciation (Nguyen et al. 2012, Dufour and Nguyen 2013). In this task, three monolingual native speakers of Spanish (male, 39 years of age, born in Mexico City), American English (male, 35 years of age, born in Seattle, Washington) and Russian (male, 25 years of age, born in the Moscow region) recorded the stimuli. The recorded stimuli were later played to the participants in random order. Concerning the task instructions, the participants were asked to listen to the words produced by native speakers and repeat after them in the following fashion: after each word, there was a pause (1 sec.) followed by a white noise (1.5 secs.), signalling the beginning of the participant's turn. Subjects had three seconds to pronounce the lexical item in question before moving on to the following word. Note that the white noise was used in order to analyse the lexical items stored in the participants' linguistic system following Nguyen et al. (2012) and to avoid a mere acoustic imitation of the stimuli.

In the second task (sentence completion), the participants had to utter sentences using the same words as the first task. In this case, images illustrating each stimulus

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and its orthographic transcription were presented on a computer screen. After analysing the image, participants were asked to utter very short sentences using the following pattern: *this* ***(stimulus)*** *is* ***(adjective)*** (e.g., *this* <u>*hornet*</u> *is scary*. In both tasks, the stimuli (targets and distractors) were randomised, and a training session with five items was carried out before each task.

The L1Spa, L1Eng and L1Rus groups completed these tasks in their native languages, while Mexican learners carried them out first in L2Eng and then in L3Rus. The approximate time spent on both tasks was 20 minutes in the case of the control groups and 35 minutes in the case of the experimental group. Owing to the amount of time spent on both tasks, Mexican learners performed them only in L2 and L3 (and not in their L1) in order to avoid tedious procedures resulting in unnatural oral performances. Thus, the L1Spa group was used as the baseline for a cross-linguistic comparison between the learners' L1 and their L2 and L3.

3.4. Data collection and acoustic analyses

Participants were recorded in a quiet room at the UNAM using the integrated microphone of a MacBookPro 15-inch (MacBook 8,2, late 2001). Several test audio files had been produced beforehand in order to ascertain appropriate quality of the recordings. The participants listened to the stimuli through headband headphones Sony XB950 (F102 dB/mW sensitivity, 24 Ω impedance, 3,000 Hz to 28,000 Hz frequency response) connected to the computer with a cord. All the audio files were saved as *.wav* files (Mono, 44100Hz, 16-bits) and acoustically examined by a phonetician (the second author) in order to guarantee the required acoustic quality for formant detection.

All the data were manually transcribed and segmented by the first author in *Praat* (Boersma and Weenink 2001). All errors (mispronunciations, hesitations or truncations) and unclear vowel formant transitions in L1/L2Eng (e.g., the cases of full rhotacisation) were labelled and excluded from the analysis. As a consequence, we analysed a total of 1,192 tokens: 136 in the L1Spa group, 132 in the L1Eng group, 117 in the L1Rus group, 419 tokens in the L2Eng group, and 388 tokens in the L3Rus group.

After this, a *Praat* script was used to extract F1 and F2 formant values at the midpoint of each vowel, as well as its duration. Finally, a Lobanov normalisation (1971) was performed in order to compare reliably male and female speakers in terms of their formant structure.

3.5. Metrics

Two metrics were used in order to assess vowel reduction. In order to examine the vowel quality of unstressed vowels, we calculated Euclidean distance (ED) following Amir and Amir (2007), Gendrot and Adda-Decker (2016), and Santiago and Mairano (2019). This metric allowed us to measure the distance between the F1-F2 point of a vowel and the acoustic centre of the triangle spanned by all the vowels in the F1 × F2 vowel chart. ED between reduced and non-reduced vowels can provide an estimate of their degree of centralisation: the shorter the ED, the more reduced unstressed vowels are. In order to achieve this objective, we first identified the acoustic centre of the vowel space by averaging the F1 and F2 values of all the vowels (for each

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speaker) extracted in our corpus. Then, we computed ED from the acoustic centre to the position of each vowel within the F1 × F2 chart (with Lobanov-normalised values) produced by each speaker. Finally, we analysed ED in accordance with their prosodic position (stressed and unstressed vowels), tasks, and vowels (letters) in every group. The second metric for assessing vowel reduction consisted in measuring the temporal values (in ms) of the vowels.

4. Analysis and results

In this section, we report the principal findings of the study. First, we present a brief description of the statistical analyses which were carried out to answer our research questions. Then we provide the reader with the acoustic values observed in terms of vowel quality (ED) and duration in different groups and tasks. The discussion and the interpretation of these results will be summarized in Section 5.

4.1. Statistical analysis

The statistical analyses were carried out in *R* (version 3.6.0, R Core Team 2018) with different linear mixed-effects models via the *lme4* package (Bates et al. 2015). We built separate models for each of the two dependent variables (ED and Duration) and for each group (L1Spa, L1Eng, L1Rus, L2Eng and L3Rus) resulting in 10 different models in total. The fixed effects in all these models were Prosodic Condition (stressed vs. unstressed), Task (word repetition vs. sentence completion) and Vowel (letters *a* vs. *e/э* vs. *o*). All the interactions among fixed effects were also estimated. Please note that it was decided to build different models for each group since our expectations for the groups differed, as detailed in Section 2.4. The random effects considered were Participant (accounting for inter-participant variability) and Word (accounting for potential lexical effects on ED and Durations). The structure of the random effects was that of maximal specification (Barr et al. 2013), including random intercepts for all random effects, and by-speaker random slopes for Prosodic Condition, Task and Vowel. All the variables were coded with sum-to-zero contrasts[3] in order to obtain meaningful values (Schielzeth 2010) and the statistical significance of our predictors was determined by calculating *p*-values *via* Satterthwaite's approximation for the estimation of the degrees of freedom with the aid of the *lmerTest* package (Kuznetsova et al. 2017).[4] Finally,

[3]The variables with sum-to-zero contrasts were coded with the help of the formula contr. sum ( ) and according to the number of levels in each fixed effect. The intercept term corresponds to the grand mean. For example, in the case of a simple contrast a= −1 and b = 1, the intercept is the average of the mean values, and the main effect is the difference of the mean of each group from the intercept.

[4]The *lmer* package does not provide *p*-values. In order to obtain them, we first performed Likelihood ratio tests of full and reduced models via ANOVA () performance. However, given the complexity of our models, we ran into convergence issues for reduced models. We thus used Satterwaite's method to obtain *p*-values for the predictors.

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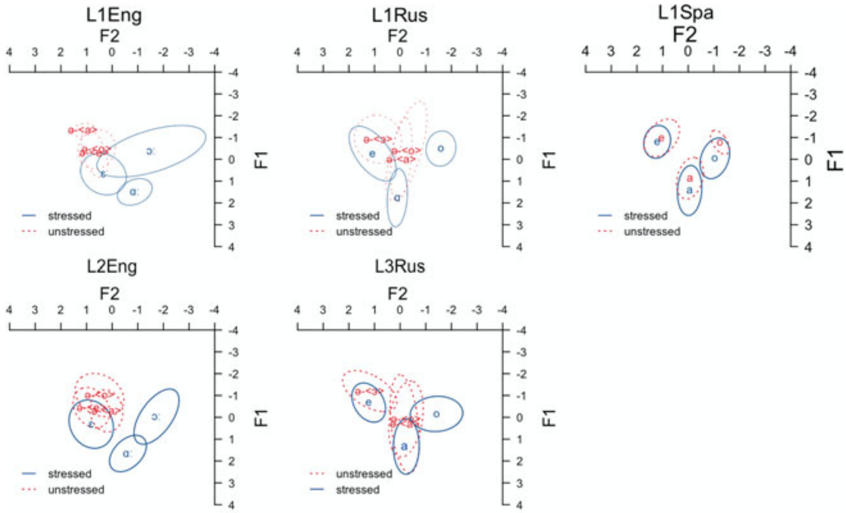

Figure 1: Bark-transformed formant values in the F1 × F2 vowel space for both prosodic conditions and groups

post-hoc comparisons were performed using the package *emmeans* (version 1.3.0) with false discovery rate (fdr) correction for multiple comparisons.

4.2. Results in ED (vowel quality)

Our first analysis consisted in comparing ED under all prosodic, task and vowel conditions for the five groups. Figure 1 presents Bark-transformed formant values in the F1 × F2 vowel space for both prosodic conditions and groups. Note that unstressed vowels in L1/L2Eng and L1/L2Rus are split according to their orthographic representations (angle brackets). According to the charts, schwas in L1Eng and L1Rus tend to occupy the centre of participants' acoustic space, whereas stressed vowels tend to be more peripheral. Note that in L1Rus, schwas associated with the letter э display more acoustic dispersion, and they overlap with the acoustic area of the stressed vowel /e/. In contrast, L1Spa unstressed vowels occupy nearly the same acoustic area as their stressed counterparts, which confirms the absence of vowel centralisation in this language.

Regarding the vowel chart of L2Eng, schwas tend to be produced as centralised vowels. The magnitude of their acoustic overlap with stressed vowels seems to be marginal. As for L3Rus, unstressed vowels display larger acoustic dispersion. The ellipses around the schwa centroids clearly exhibit more variability across learners. The centroids of the L3Rus schwas associated with the letters *o* and *a* are located near the acoustic centre of the learners' vowel space, indicating the presence of centralisation. However, ellipses containing these schwas also show that many of them were produced similarly to an open vowel /a/. In the case of the schwas associated with the letter э, we observe that the learners seem to have difficulty in producing

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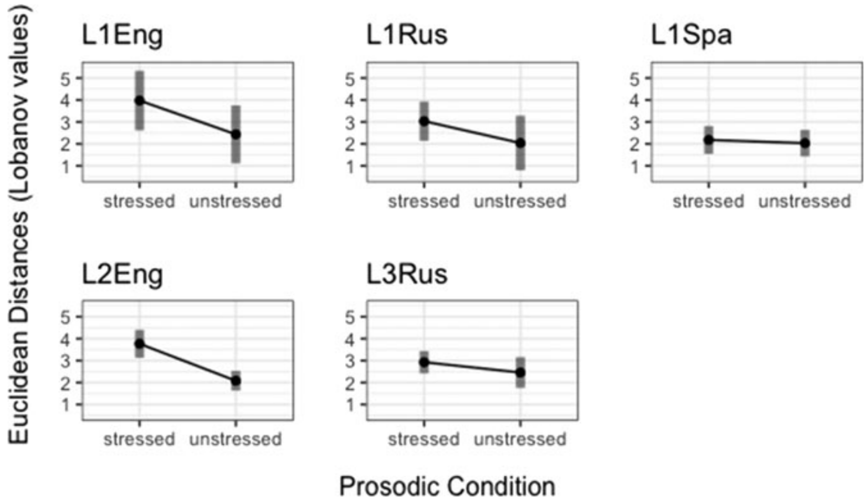

Figure 2: ED values by Prosodic Condition and Group. Bars indicate 95% CIs.

centralised vowels: acoustic realisations of this letter largely overlap with those of the stressed vowel /e/. This suggests that some unstressed vowels in L3Rus display some kind of centralisation, but in other cases, they are produced with a similar vowel quality to their stressed counterparts (vowels /e/ and /a/, mainly).

Figure 2 presents the ED means of stressed vs. unstressed vowels produced by the five groups (Tasks and Vowels collapsed). Note that the y-axis values represent squared-values of the z-scores obtained with Lobanov normalisation (1971). This figure suggests clear differences across the groups in accordance with the observations described above. On the one hand, both native speakers of English and Mexican learners of L2Eng produced vowel centralisations since ED is shorter in unstressed vowels than in their stressed counterparts. Contrary to this, ED in L1Spa does not differ between stressed and unstressed condition. However, the ED of unstressed vowels in L1Rus tends to be shorter than for stressed ones, but these differences are not as salient as the ones observed in L1/L2Eng. Concerning L3Rus, ED is similar in both prosodic conditions, even though there is a tendency towards centralisation. We report ED mean values under the two prosodic conditions in Table 1.

In order to test these differences statistically, we built five different linear mixed-effects models predicting ED values as a function of Prosodic Condition, Task and Vowels and all their interactions for each of the five groups: L1Eng, L1Rus, L1Spa, L2Eng and L3Rus as specified in section 4.1. Participant and Word were entered as random effects with by-participant random slopes for all fixed effects. Model summaries and other details can be found in the Appendices, while the significance of predictors is reported in Table 2.

The main effect of Prosodic Condition tended to significance in the case of L1Eng ($p = .07$) and L1Rus ($p = .08$). In other words, differences between the

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Group	ED mean values (Task and Vowel collapsed)	
	Stressed position	Unstressed position
L1Eng	3.97	2.43
L1Rus	3.03	2.04
L1Spa	2.18	2.03
L2Eng	3.80	2.03
L3Rus	2.93	2.46

Table 1: ED mean values by groups and prosodic conditions.

ED mean values reported in Table 1 are statistically different: we observed shorter ED for unstressed vowels, but longer ED for their stressed counterparts. Note that this variable interacted significantly with Vowel for L1Eng ($p = .006$) and L1Rus ($p = .047$), meaning that the centralisation is realised with different patterns across the three orthographic representations in question. Post-hoc comparisons with *fdr* correction on Model-L1Eng revealed that ED is shorter in unstressed vowels associated with the letter *o* ($\beta = 5.22$, $SE = 1.09$, $p = .025$). However, these differences were very small, and non-significant in the case of the schwas associated with the letters *a* and *e* (all *p*-values > .05). Post-hoc comparisons with *fdr* correction on Model-L1Rus revealed a similar tendency: vowel centralisation was observed in unstressed vowels associated with the letter *a* ($\beta = 2.47$, $SE = .81$, $p = .08$), but not in those associated with the letters э and *o* (all *p*-values > .05). In Model-L1Spa, the main effect of Prosodic Condition was not significant ($p = .87$), confirming that there is no vowel centralisation in this language.

In the case of the learners, the statistical analyses revealed that the main effect of Prosodic Condition was highly significant when they produced L2Eng vowels ($p < .0001$), confirming that schwas in L2Eng were centralised. This model also revealed a significant interaction of Prosodic Condition and Vowel ($p < .001$). Post-hoc comparisons revealed that ED is shorter in the schwas associated with the letters *a* ($\beta = 2.47$, $SE = .81$, $p = .081$) and *o* ($\beta = 2.04$, $SE = .79$, $p < .051$), but not in those associated with the letter *e* ($p = .88$).

Regarding the production of schwas in L3Rus by the same learners, the main effect of Prosodic Condition was not significant ($p = .317$). However, this variable interacted significantly with Vowel ($p < .005$). Post-hoc comparisons revealed that centralisation is observed in the case of the letters *a* ($\beta = 1.25$, $SE = .45$, $p < .02$) and *o* ($\beta = 1.82$, $SE = .49$, $p < .002$), but not э ($p = .53$).

Finally, all the models also demonstrated that the main effect of Task on ED is not significant. This variable was not involved in any interaction (all *p*-values > .05). Thus, Task was not a relevant predictor of vowel centralisation for any group.

In order to compare the degree of centralisation across groups, we observed estimates for the main effect of Prosodic Condition in each of the five models. A larger estimate indicates greater ED between stressed and unstressed vowels, and therefore a

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	p values				
Fixed effects	Model 1 L1Eng	Model 2 L1Rus	Model 3 L1Spa	Model 4 L2Eng	Model 5 L3Rus
Prosodic Condition	.073	.084	.877	<.0001	.317
Vowels	.170	.765	.312	<.0001	.865
Task	.397	.863	.357	.864	.683
Prosodic Condition × Vowels	.006	.047	.069	<.0001	<.0001
Prosodic Condition × Task	.910	.210	.744	.111	.616
Vowels × Task	.480	.891	.074	.491	.396

Table 2: Statistical significance of the fixed effects predicting ED across the five groups.

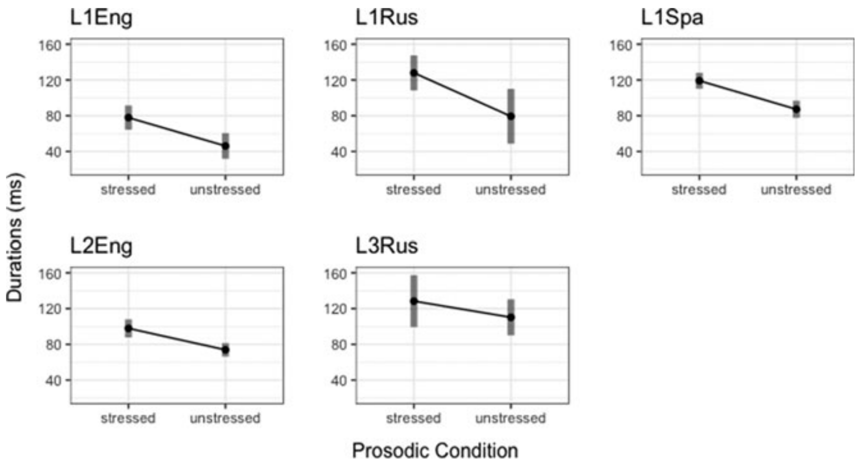

Figure 3: Durations of the vowels by Prosodic Condition and Group (Vowels and Task collapsed). Bars indicate 95% CIs.

greater degree of centralisation. Estimates of Prosodic Condition for L1Eng (0.76) and L1Rus (0.49) indicate that L1Eng produce a higher degree of centralisation compared to L1Rus. The extremely low estimate for L1Spa (0.07) shows once again that centralisation is virtually non-existent in this group. As for the learners, the degree of centralisation in L2Eng is comparable to L1Eng (0.88). Thus, Mexican learners produced schwas displaying similar centralisation to those produced by native speakers of English. Our first expectation is thus confirmed: learners are not influenced by their L1 (Mexican Spanish) and are able to produce centralised L2Eng vowels in a native-like way. Similarly, estimates for Model-L3Rus (0.45) reveal a comparable amount of centralisation as for L1Rus. However, in contrast to L1Rus, the L3Rus group did not reach statistical significance in terms of the main effect of Prosodic Condition.

4.3. Results in temporal values (durations)

After studying the main acoustic cue of vowel reduction (centralisation in acoustic space), we proceeded to analyse the secondary acoustic cue of reduction, namely duration. This analysis was carried out in the same way as ED: by examining durations (milliseconds) of all tokens under prosodic, task and vowel conditions for L1Spa, L1Eng, L1Rus, L2Eng and L3Rus separately. Figure 3 illustrates the overall mean values of vowel durations by each Group (Task and Vowels collapsed).

Many considerations arise from these results. Once again, it appears that unstressed vowels were produced with shorter durations in all the groups. Nonetheless, we observed that L3Rus stressed and unstressed vowel durations display higher variability than all the other groups. We built five different linear mixed-effects models predicting Duration as a function of Prosodic Condition, Task and Vowel and all their interactions for each of the five groups, as specified

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in Section 4.1. Participant and Word were entered as random effects with by-participant random slopes for all fixed effects. Model summaries and other details can be found in Supplementary Materials, while the significance of predictors is reported in Table 3.

The output of these statistical models revealed that the main effect of Prosodic Condition was highly significant for L1Eng ($p = .005$), L1Rus ($p = .007$), L1Spa ($p < .0001$). The models also revealed that the interaction of this variable with Task was significant in L1Eng ($p = .002$) and tended to significance in L1Rus ($p = .07$). This suggests that the difference in duration between stressed vs. unstressed vowels was greater in the repetition than in the sentence completion task. While unstressed vowels were shorter than stressed vowels in both tasks, post-hoc comparisons with *fdr* correction on Model-L1Eng revealed that stressed vowels durations did not differ across tasks (p = .50) and unstressed vowels were significantly shorter in the repetition task ($\beta = -10.7$, $SE = 4.65$, $p = .051$). Post-hoc comparisons on Model-L1Rus showed that unstressed vowels displayed shorter durations in the repetition task ($\beta = -58.80$, $SE = 14.7$, $p = .015$) and this difference tended to significance in the sentence completion task ($\beta = -38.33$, $SE = 14.6$, $p = .052$). However, stressed vowel duration did not differ across tasks, nor did it differ for unstressed vowels (all p-values > .05). Finally, this interaction did not reach statistical significance in L1Spa ($p = .929$), suggesting that the effect of Prosodic condition was the same across tasks. As for learners, the main effect of Prosodic Condition was highly significant in L2Eng (p = .003), showing that unstressed vowels were shorter. Additionally, this variable interacted significantly with Task (p = .020) and post-hoc comparisons showed that stressed vowels were shorter in the sentence completion task than in the repetition task ($\beta = -11.66$, $SE = 4.18$, $p = .026$), whereas the duration of unstressed vowels was not affected by the task type ($p = .86$).

These results show that duration differences across the two prosodic conditions were more salient in the repetition task, similarly to what has been observed in L1Eng and L1Rus. Finally, the output of Model-L3Rus showed that the main effect of Prosodic Condition was not significant ($p = .168$): learners struggle to produce shorter temporal patterns for unstressed vowels when they speak in their third language. Nevertheless, the Prosodic Condition*Task interaction reached significance ($p = 0.007$). Post-hoc comparisons revealed that unstressed vowels tended to be shorter than stressed vowels in the repetition task ($\beta = -75.21$, $SE = 24.6$, $p = .053$), but these differences were marginal in the sentence completion task ($\beta = -8.17$, $SE = 18.5$, $p = .67$), that is to say, vowels were articulated with quasi-identical durations (147 ms and 139 ms for stressed and unstressed positions respectively).

To sum up, we found that the magnitude of temporal differences across the prosodic conditions is greatest in the repetition task for all groups, and tends to be smaller in the sentence completion task for native speakers (except for the L1Spa group) and L2Eng, but disappears for L3Rus. This indicates that the learners were able to exploit temporal cues to distinguish between stressed and unstressed vowels when repeating isolated words, but they failed to do so when producing the same words in short sentences in L3.

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Fixed effects	*p* values				
	Model 6 L1Eng	Model 7 L1Rus	Model 8 L1Spa	Model 9 L2Eng	Model 10 L3Rus
Prosodic Condition	.005	.007	<.0001	.003	.168
Vowels	.819	.273	.315	.909	.185
Task	.321	.917	.109	.090	.050
Prosodic Condition × Vowels	.419	.169	.421	.785	.166
Prosodic Condition × Task	.002	.076	.929	.020	.007
Vowels × Task	.129	.097	.327	.524	.147

Table 3: Statistical significance of fixed effects predicting Duration across the five groups.

Group	DURATION mean values in milliseconds in the repetition Task (Vowels collapsed)	
	Stressed position	Unstressed position
L1Spa	124.0	91.8
L1Eng	79.3	40.8
L1Rus	133.6	74.8
L2Eng	105.5	73.9
L3Rus	155.5	80.3

Table 4: DURATION mean values in milliseconds across the five groups and prosodic conditions.

This perhaps is not surprising, given the fact that this task requires a heavier cognitive load and the use of more complex cognitive functions. When learners produced short sentences in L3Rus, we observed that duration differences were not only neutralised across the prosodic conditions but also showed the highest amount of variability. This suggests that the learners were more affected by the cognitive load of the task, which may have led to slower speech/articulation rates.

For this reason, we compared the ratios of stressed and unstressed vowels in the repetition task using the DURATION mean values reported in Table 4. It was also decided to determine whether CLI is observed in this cue. This allowed us to exclude the confound of variable articulation rates.

We found that the amount of temporal reduction is similar in L1Eng and L1Rus (49% and 44% respectively), while the values for L1Spa (26%) differ substantially. These values are in line with the previous descriptions, which means that the differences between the temporal ratios of stressed and unstressed vowels are more important in stress-timed languages like English (Ladefoged 1999, Roach 2009, Ladefoged and Johnson 2011) or Russian (Avanesov 1956, Knyazev and Pozharitskaya 2005, Iosad 2012) than in syllable-timed languages like Spanish (Quilis and Fernández 2003, Martín Butragueño 2014).

Concerning the learners, temporal ratios in L2Eng (30%) are halfway between those obtained in L1Spa and L1Eng, while temporal ratios in L3Rus (48%) differ completely from those observed in L1Spa, reaching native-like targets. We note that the ratio differences ought to be experimentally tested in future studies.

These findings indicate that, in contrast to ED, the differences between the temporal values reached statistical significance. This suggests that learners do not find it difficult to produce shortening for unstressed vowels in L3Rus, at least in the repetition task. Since the L2 and L3 values differ, these findings challenge the idea of CLI: both from the L2 to the L3 and from L1 to the L2/L3.

Finally, all the models showed that durations were not affected by the interaction PROSODIC CONDITION*VOWEL (all p-values > .05). In comparison to the ED results, the duration differences between stressed and unstressed vowels were not related to orthographic representations, in our experiment.

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5. Discussion

One of the main objectives of this investigation was to examine CLI in Mexican multilingual learners by analysing the production of unstressed vowels in L2Eng and L3Rus in two different tasks. To this end, we assessed vowel centralisation with regard to spectral changes (via Euclidean distance) and temporal values. Afterwards, both types of vowel analysis were compared with the values obtained in the three control groups: native speakers of Mexican Spanish, American English and Russian. In addition, another goal of this research was to discuss these findings in light of previous studies and current L3 acquisition models. In this section, we would like to address the principal research questions of our work.

RQ 1: *To what extent are Mexican learners of English as an L2 and Russian as an L3 capable of producing vowel reduction in these languages when performing two types of tasks (delayed repetition task vs. sentence completion task)?*

Our findings show that intermediate-advanced Mexican Spanish learners produce vowel centralisation in L2Eng via both spectral changes and temporal durations. In contrast to the previous studies (Gómez Lacabex et al. 2005, Diettes 2014), which showed that learners with syllable-timed native languages experience difficulty in producing unstressed vowels in stress-timed target languages like L2 English, our results demonstrate that this is not the case for this group of Mexican Spanish speakers. These learners are able to avoid relying on their L1 phonetic cues (both temporal patterns and quality changes) when producing the stressed-unstressed vowel contrasts of L2 English. Interestingly enough, the learners produced almost all schwas in L2Eng in a native-like way (via spectral changes), although vowel reduction rates did not coincide completely with observed in L1Eng. Regarding vowel quality (ED), the results are in line with Byers and Yavas (2017) and Trofimovich and Baker (2006), who found that the difficulty in producing reduced vowels in L2 English tends to disappear with sufficient exposure to L2 input (both in formal and informal learning contexts), even when the learners' L1 does not have phonological reduction.

Unlike L2Eng, learners find it difficult to produce vowel reduction in L3Rus: whereas the stressed-unstressed vowel contrasts are clearly marked in their production by shorter temporal values in the repetition task, not all of them produced this contrast via spectral changes. The great amount of variability observed in ED indicates that L3Rus schwas were not homogenously produced in terms of centralisation. Our first prediction — the claim that these learners should produce some kind of vowel centralisation uncharacteristic of L1Spa — is thus confirmed: vowel centralisation is produced via spectral changes in the L2 and via temporal patterns in the L3. It was also demonstrated that unstressed vowels in L2Eng and L3Rus do not display similar vowel quality to the L1Spa unstressed vowels of the control group.

Our results also suggest that vowel reduction produced by multilingual learners displays an extremely complex picture. When the effect of vowels on ED was taken into consideration, it was discovered that the learners produced unstressed L2Eng vowels in a native-like fashion in the letters *a* and *o* (in such words as *sug<u>a</u>r* or

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manor), but not in the letter *e* (in such words as *elder*), in which a great amount of variability was observed. In fact, a similar tendency was detected in the L1Eng control group: whereas clear centralisation is registered in the schwas represented by the letter *o*, no clear differences emerge in the letters *a* and *e*, in which, in contrast to the learners, we observed a tendency towards centralisation without any statistical significance.

A somewhat similar pattern was also revealed in the L3Rus. Our data show that Mexican learners are capable of producing L3Rus schwas with similar native spectral values when they were associated with the letters *a* and *o* in words like *побе́да* and *ребё́нок*, but not in the letter э in words like *экипа́ж*. Russian speakers produced clear centralisations in the schwas represented by the letter *a*, but not in those represented by the letters э and *o*, in which differences did not reach statistical significance. Unexpectedly, these findings appear to be in contradiction with the description of vowel reduction in Russian provided by Avanesov (1956), Knyazev and Pozharitskaya (2005) and Iosad (2012). We argue that that this may be due to inherent acoustic properties of the schwa in Russian. According to our metrics, unstressed Russian vowels may result in a different kind of centralised vowel [ə] from English. Russian schwas are further away from the acoustic centre of the participants' vowel space with respect to their stressed counterparts, suggesting that this vowel is more anterior than the typical [ə]. However, a higher number of Russian speakers and more controlled data may be needed to corroborate this hypothesis.

Another interesting observation in terms of the L2Eng and L3Rus data is that learners experienced considerable difficulty in producing the schwa represented by the letter *e*. A possible explanation of these findings could be the phonetic and perceptual proximity of /e/ and /ə/ in L2Eng and L3Rus in the minds of Mexican learners, which may make both phonemes assimilate into a unique category /e/ in their interlanguage (see the SLM by Flege 1995, 2005), whereas this is not the case for the rest of the phonemes. An alternative explanation may be related to methodological issues with our experiment. In both L1/L2Eng, these unstressed vowels displayed rhotacisation affecting ED metrics. As for L1/L3Rus, words containing the letter э in unstressed conditions were mostly of foreign origin (эшело́н 'step' and экипа́ж 'crew'). It is possible that the participants produced full vowels in these contexts.

Some studies have pointed out that the task type, and more particularly, the presence of written input, has a non-facilitative effect on L2 vowel reduction (Flege and Bohn 1989, Gor 1999). Our results show that the task does not play a significant role in the production of unstressed vowels, as far as vowel quality is concerned: the word repetition task and the sentence completion task did not affect the ability of subjects to produce unstressed vowels in their L2Eng and L3Rus. On the other hand, we discovered that temporal patterns can be affected by the task type: in the sentence completion task, longer durations in unstressed vowels were observed. A possible explanation of our findings might be the fact that semi-spontaneous speech is related to low speech rates: the sentence completion task demands more complex cognitive functions than word repetition. As a result, some speakers may lengthen

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vowels to gain some time and prepare their reply. This effect, it must be noted, mainly affected the learners when they spoke in L3Rus.

RQ 2: *Do Mexican learners of Russian as an L3 who have already acquired L2 English benefit from this knowledge, in terms of vowel reduction? In other words, to what extent will the L2 exert CLI on the L3?*

Mexican learners do not seem to experience any difficulty in producing vowel centralisation in L2 English, even though temporal vowel ratios do not completely reflect native-like values. However, as was explained earlier, this was not necessarily the case in L3Rus. Concerning the findings of the other studies in this field, it was shown that previous non-native languages may facilitate the acquisition of different sound patterns in the L3. For instance, studies of Enomoto (1994) and Onishi (2016), whose main focus was the performance of multilingual learners in both L2/L3, support this point of view. Nevertheless, our results would seem to suggest that facilitative CLI from L2Eng on L3Rus is not observed homogeneously across all learners. In other words, whereas all the learners tend to be able to produce schwas in L2Eng with similar phonetic cues, they struggle to produce schwas in L3Rus. Note that non-facilitative CLI from their L1Spa to L3Rus is not observed, since estimates for L1Spa (0.07) and L3Rus (0.45) indicate that learners seem to produce vowel reduction in their L3, even though this process does not homogenously apply across all the participants. All in all, this does not fully confirm the claims put forward in the L3 acquisition literature: learning to produce new sounds in an L2 does not always facilitate the acquisition of similar sounds in an L3. At the same time, our results also indicate that the acquisition of the spectral quality of schwas in an L3 does not seem to be completely determined by the L1 either.

Furthermore, it is important to highlight that L3Rus schwas tend to be articulated with similar acoustic quality as in L1Rus, even though this tendency was not homogenously supported by the statistical analysis of the main effect of Prosodic Condition. Regarding the learners' temporal patterns, we observe that temporal ratios in L3 displayed more native-like performance, although this was not completely the case in the L2. This observation partially confirms the idea of CL1 from the L2 to the L3.

RQ 3: *What kind of CLI will be observed between the L1, L2, and L3 and how will it be interpreted in the light of the current L3 phonological studies?*

According to the predictions of the LPM, the learners of L3Rus were expected to transfer vowel reduction from the L2 to the L3, since this phenomenon is phonological in these languages, while it is merely phonetic in L1Spa. The L2SFM pointed to a similar conclusion: we expected to observe the same kind of transfer from the L2 to the L3 owing to the cognitive similarity of their process of acquisition. Nevertheless, we were unable to establish a link between the L2 and the L3 in terms of vowel quality and duration: our results do not show clear transfer from the L2 to the L3 in this respect. While the learners tended to rely on quality cues in their L2, they made use of duration cues in their L3. We failed to collect any significant evidence for a resemblance between the acquisition patterns of the two languages.

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Nonetheless, as these learners were unable to reach completely native-like values in both their L2Eng and L3Rus in terms of vowel centralisation or temporal values, we might suppose that the L2 and the L3 phonologies of these learners were constrained by their L1Spa. It appears that the L1Spa might have prevented native-like acquisition of vowel reduction in both phonologies (see Flege 1995, Gass and Selinker 2001).

Finally, vowel reduction may be such a complex phenomenon that the Mexican learners were not able to transfer it successfully from one language to the other. In this regard, Barnes (2006) notes that spectral centralisation tends to appear in languages with a pronounced temporal contrast between stressed and unstressed syllables. However, since these learners did not produce canonical values in some contexts in their L2 and L3 either in terms of centralisation or duration values, it appears that they ended up with hybrid values, which reflect the features of stressed-timed and syllable-timed languages simultaneously.

6. Theoretical Implications

Superficially, Mexican learners of L2Eng and L3Rus were successful in acquiring vowel reduction in different ways, suggesting a transfer from L2 to L3, in accordance with the LPM and the L2SFM. However, vowel reduction was acquired in different ways in each language. While learners tended to use quality cues in the L2, they relied on duration cues in the L3. These findings seem to confirm the results obtained by Byers and Yavas (2017) and Trofimovich and Baker (2006). Sufficient exposure to L2 (or L3) input might help learners acquire such complex phonological phenomena as vowel reduction. Even though the link between this process in the L2 and the L3 was not established, our findings are in line with Enomoto (1994) and Onishi (2016): Mexican multilingual learners acquired vowel reduction in both their L2 and L3 and far outperformed the L2 Spanish-speaking learners of English described in other studies (Gómez Lacabex et al. 2005, Diettes 2014).

Nonetheless, the predictions made by LPM and the L2 Status Factor Model must be rejected, as numerous differences were observed between the acquisition patterns in the L2 and the L3. We believe that the similarity between the linguistic phenomena in the process of acquisition and the resemblance between the cognitive processes taking place in the L2 and the L3 are not sufficient to be able to make accurate predictions about the direction of CLI. Possibly, the L2 and the L3 need to be typologically related and contain similar linguistic structures to facilitate interlanguage interaction (e.g., production of full vowels in L2 Spanish and L3 Italian).

We also reached the conclusion that these learners' phonologies were constrained by their L1 as they produced hybrid values both in their L2 and L3. It is possible that the vowel reduction patterns from their L1 prevented them from acquiring vowel reduction in the L2 and the L3 phonologies (Flege 1995, Gass and Selinker 2001).

Our findings suggest that there is currently a strong need for an L3 acquisition model that could account for not only the influence of the L1 or the L2 on the L3 but also for complex patterns of interaction between all languages involved in L3

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acquisition. Furthermore, this theory must also account for various extralinguistic variables (e.g., psychotypological similarity and phylogenetical distance between the L2 and the L3, the level of command of the L2 and the L3, the age of the onset of all languages, etc.). Consequently, it must be capable of explaining all kinds of hybrid and interlanguage interactions that may be observed in the production of L3 learners.

Finally, we acknowledge that there are certain limitations affecting this study. Firstly, some issues regarding the metrics used in this research must be raised. In most studies focusing on vowel reduction produced by bilingual learners, vowel quality is examined in terms of F1/F2 formant differences extracted from learners' and native speakers' oral productions. In our investigation, we could not make use of this option, since several phonological systems were compared: L1Spa, L1Eng, L1Rus, L2Eng, and L3Rus. For this reason, it was decided to use a metric assessing the degree of centralisation to clarify cross-linguistic comparisons, namely, Euclidean distance (ED). However, this metric does not allow one to ascertain whether centralised vowels in the L1/L2Eng and the L1/L3Rus vowels displayed a similar formant structure, but rather to what extent vowels are located near the acoustic centre of the vowel space. Secondly, statistical analyses carried out on a sample size of 18 learners in the experimental group and five to six native speakers in the control groups have limited statistical power.[5] Quantification of this phenomenon with more participants could be carried out in future studies to corroborate our results. We also believe that the results obtained in this study might have changed if a different coding system had been employed for categorical variables, where the vowels behaving in the most target-like (or consistent) manner could have been used as the reference levels. We leave this important issue to future replications of this investigation.

The main significance of this exploratory study lies in the expansion of knowledge concerning the production of vowel reduction by multilingual learners. A great number of L3 studies focus on well-studied phonetic phenomena in both L1/L2, such as VOT (e.g., Wrembel 2015). Unfortunately, L3 vowel reduction has not yet been well described. Our goal was to shed light on the acquisition of this highly complex phenomenon by examining the performance of learners who are developing linguistic skills in various foreign languages. The findings of our study reveal that Mexican multilingual learners of L2Eng and L3Rus are able to avoid relying on their L1 phonology when producing vowel reduction in foreign languages, and, in some cases, they are capable of producing native-like patterns.

7. Conclusions

This investigation represents an exploratory study of vowel reduction by Mexican learners of L2 English and L3 Russian. This study demonstrated the complexity of

[5]Nonetheless, it must be pointed out that most L3 studies are carried out on relatively small groups, since finding multilingual language learners with a specific profile is extremely difficult.

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interlanguage interaction in multilingual learners. Further work needs to be carried out in this area (e.g., more participants, different sets of languages, focus on other phonemes, etc.) in order to obtain better understanding of the acquisition of vowel reduction. For example, further studies could target the acquisition of vowel reduction by speakers of a syllable-timed L1 (Spanish, Italian, French, etc.) who are acquiring phylogenetically close vowel-reducing L2s and L3s (e.g., English and German, or English and Dutch).

In conclusion, we believe that the present research may serve as a starting point for further analyses of vowel reduction in multilingual learners and contribute to the general understanding of cross-linguistic influence.

Supplementary Materials

To view supplementary material for this article, please visit http://doi.org/10.1017/cnj.2022.6.

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