

GEMINATE REARTICULATION IS PSYCHOACOUSTICALLY ROBUST: PHONETIC IMITATION OF POLISH GEMINATES BY SPANISH-CATALAN BILINGUALS

Arkadiusz Rojczyk¹, Lucrecia Rallo Fabra²

¹Speech Processing Laboratory, University of Silesia in Katowice
arkadiusz.rojczyk@us.edu.pl

²Interdisciplinary Speech & Language Acquisition Laboratory
Universitat de les Illes Balears
lucrecia.rallo@uib.es

ABSTRACT

The study investigates to what extent rearticulation observed in Polish geminates may be imitated by speakers of Catalan, a language with single-articulated geminates. Polish geminates have optional rearticulation, which appears to be a unique feature of Polish compared to other languages with consonantal gemination. To our knowledge, this is the first study to investigate this phonetic property in phonetic imitation. A total of 20 participants (10 speakers of Catalan and 10 speakers of Polish) took part in the experiment which included three blocks: baseline (read the words); imitation (imitate the model talkers' productions); post-test (read the words again). The results revealed that Catalan speakers imitated rearticulation very effectively, matching the native Polish participants. Moreover, the post-test analyses showed that they retained rearticulation in more than 50% of their productions. We interpret these results in terms of the psychoacoustic robustness of geminate rearticulation and phonetic imitation in a non-native language.

Keywords: geminate consonants, rearticulation, phonetic imitation, second-language speech

1. INTRODUCTION

The accumulating studies on phonetic imitation in a second or foreign language provide evidence that speakers are able to imitate phonetic properties that are absent in their native language after being exposed to a model talker of a foreign language. This effect has been found for multiple spectral and temporal features such as VOT [1, 2, 3], vowel duration [4, 5], formant frequencies of vowels [6, 7, 8, 9], suppression of the release in stop consonants [10], t-glottaling [11], or suprasegmentals [12, 13]. The robustness of imitation is measured as the magnitude of emergence or suppression of a given feature in productions that shadow a model talker in relation to default productions in a baseline condition in which the speakers read a set of words or phrases without any audio prompts. Moreover, the weight of

feature retention, sometimes referred to as a carry-over effect, is measured in post-imitation productions. The results from these studies show that L2 learners may temporarily bypass their L1 pronunciation habits and converge with a model talker towards an L2 native-like norm by modifying phonetic properties of their speech. The analysis of post-imitation productions suggests that at least some of the imitators retain the imitated features in subsequent non-imitative productions.

The common denominator of a large number of previous studies on L2 phonetic imitation is that they use English as a target language and they recruit learners, usually of higher proficiency, of the imitated language. Accordingly, relatively little is known about how phonetic imitation works for features that are absent in English and how they are shadowed by imitators who have had no prior exposure to the imitated language. In the current study we fill this gap by investigating the magnitude of phonetic imitation of the phenomenon of rearticulation in Polish consonantal geminates by Spanish-Catalan speakers without any prior formal learning or communicative command of Polish.

2. REARTICULATION IN POLISH GEMINATES

The production of Polish consonantal geminates is characterised by optional rearticulation. Rearticulation in Polish appears to be a rare, if not unique, feature, since it is, to our knowledge, unattested word-internally in any other geminating language. There is a significant between-speaker variation in the articulation type in that some speakers will tend to single-articulate while others will produce most tokens as rearticulated [14, 15]. The rearticulation rate may also depend on the consonantal group, the largest rate was found for affricates, followed by stops, nasals and fricatives [16].

Rearticulation in Polish geminates is manifested as an audible and observable central disruption or discontinuity in the geminate portion. The result is a

sequence of two homorganic consonants, each having its own release burst, rather than one uniform long consonant as in the case of single-articulated geminates. Figure 1 shows visualisation of a single-articulated velar stop geminate in the word *lekka* ‘light’. The occlusion portion is undisrupted, indicating the production of the /kk/ as one long consonant. Figure 2 shows the rearticulated /kk/ in the same word *lekka* ‘light’. Rearticulation emerges as the visible release of the first /k/.

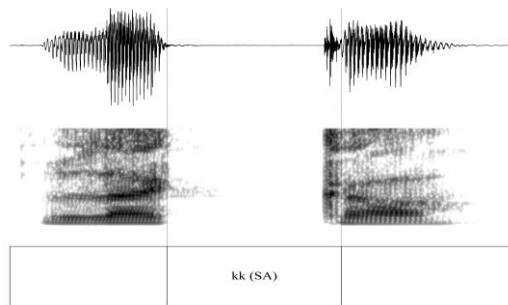


Figure 1: Single-articulated production of the word *lekka* ‘light’. The geminate does not have any discontinuities in its total portion

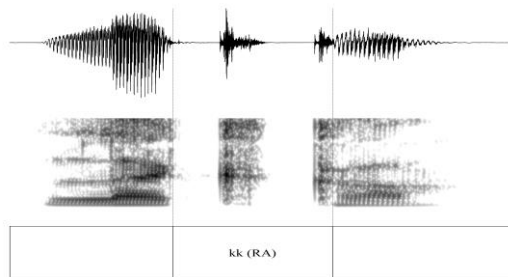


Figure 2: Rearticulated production of the word *lekka* ‘light’. Observable release of the first consonant in the central part of the geminate occlusion.

Similar to Polish, Catalan has consonantal geminates, especially sonorant geminates are quite common both in Peninsular Catalan and Majorcan Catalan [17, 18], however, unlike in Polish, they do not form lexical minimal pairs with their singleton counterparts and they are never rearticulated. Accordingly, we hypothesised that Majorcan Catalan speakers would be able to imitate geminate consonants of an unknown language such as Polish, provided that gemination would be signalled in the spelling.

3. THE CURRENT STUDY

In this study we test whether the Catalan speakers would be able to imitate rearticulation of geminates in Polish. More specifically, we address the following research questions:

1. What is the magnitude of imitation of rearticulation by speakers of Catalan?
2. How does the imitative performance of Catalan speakers compare to the one by native speakers of Polish?
3. What is the magnitude of post-imitative retention of rearticulation in subsequent non-imitative productions?

3.1. Participants

Ten native Spanish-Catalan bilinguals (9 females and 1 male) were recruited for the Catalan group. They were all students and staff at the University of the Balearic Islands in Palma de Mallorca, ranging in age from 20 to 28 years ($M = 21.5$). For 6 participants Catalan was a dominant language, 4 participants reported that it was their second language. The Polish group consisted of 10 native speakers of Polish (7 females and 3 males) with the mean age of 24.6 years (range: 23 to 28). They were all students of the University of Silesia in Katowice. All of them were born and resided in Poland. None of the speakers in either group reported any speech or hearing disorders nor had any indication of such.

3.2. Materials

The materials consisted of 10 two-syllable singleton-geminate pairs with stop and nasal consonants. In order to maintain maximum spelling-to-production clarity for Catalan speakers, some of them were existing lexical units in Polish and some of them were phonologically potential words. Slight spelling changes were made to assist Catalan speakers, for example the Polish orthographic representation ‘w’ for a voiced labiodental fricative /v/ was altered into ‘v’. Table 1 shows the word tokens used in the experiment.

singleton	geminate	singleton	geminate
<i>leka</i>	<i>lekka</i>	<i>seni</i>	<i>senni</i>
<i>pana</i>	<i>panna</i>	<i>dana</i>	<i>danna</i>
<i>vana</i>	<i>vanna</i>	<i>maki</i>	<i>makki</i>
<i>leki</i>	<i>lekki</i>	<i>rana</i>	<i>ranna</i>
<i>maka</i>	<i>makka</i>	<i>paka</i>	<i>pakka</i>

Table 1: Singleton-geminate pairs used in the experiment.

Two male model talkers (native speakers of Polish, qualified phoneticians) recorded the audio prompts for the imitation task. Each of them produced two types of articulation for each geminate: rearticulated and single-articulated. They were recorded in a sound-proof booth in the Speech Processing

Laboratory, University of Silesia in Katowice using a headset dynamic microphone Sennheiser HMD 26 powered by a USBPre2 (Sound Devices) preamplifier at 44 100 Hz. Visualisations of the recorded prompts confirmed that the targeted rearticulated productions had expected discontinuities in the geminate portion.

3.3. Procedure

The experiment consisted of three blocks: (1) baseline; (2) imitation; (3) post-imitation. In the baseline block, the Catalan imitators were informed that they would be presented with words from a foreign language and their task was to show how they thought these words should be pronounced. None of the Catalan participants had any difficulties with confident productions owing to clear spelling-to-sound representations. The Polish imitators were instructed to read the words in Polish in their default pronunciation. In the imitation block, both groups were instructed to shadow the pronunciation of the voices (2 model talkers) they would hear as faithfully as they could immediately after the audio prompts. The rearticulated productions were counterbalanced with an equal number of single-articulated productions. Orthographic representations were provided to facilitate the correct production of whole word forms. In the post-imitation block, the participants were asked to read the tested words again from orthographic representations.

The words were presented in black 80-point font against white background on a laptop (Catalan group) and monitor (Polish group). The items were randomised for each imitator in each block. The audio prompts were delivered through headphones integrated with a headset microphone at a comfortable listening level of 70 dB. The Catalan group was tested in a quiet room in the Interdisciplinary Speech & Language Acquisition Laboratory, University of the Balearic Islands in Palma de Mallorca. The Polish group was tested in the Speech Processing Laboratory, University of Silesia in Katowice. Both groups were recorded with a dynamic headset microphone Sennheiser HMD 26 fed by a USBPre2 (Sound Devices) amplifier with the signal captured at 44 100 Hz. The microphone was positioned approximately 5 cm directionally from the speaker's mouth.

3.4. Measurement and analysis criteria

The collected geminate productions were binary coded as rearticulated or single-articulated. Rearticulation was defined as an observable disruption or discontinuity in the geminate portion indicating the release of the first consonant. There

were 40 geminate word forms analysed for each speaker (baseline: 10; imitation 20 (2 model talkers); post-imitation: 10), giving a total of 800 analysed productions. The binary codes were recalculated as proportions of rearticulations for each speaker and each task ranging from 0 to 1. The Mixed Model ANOVA was designed with speaker as a random effect, task and language as fixed effects, and the rearticulation rate as a dependent variable. This model estimates the variance of random factors by constructing sums of squares and cross product matrix for independent variables by using Satterthwaite's method of denominator synthesis.

4. ANALYSIS AND RESULTS

The analysis of the Catalan group showed a robust effect of imitation – the speakers in this group imitated rearticulation at the mean rate of 0.83 ($SE = 0.1$) compared to 0 in the baseline condition. Rearticulation was retained in more than half of the productions ($M = 0.55$; $SE = 0.09$) in the post-test task. There was a significant main effect of task on the rearticulation rate [$F(2, 18) = 40.94$, $p < 0.001$, $\eta_p^2 = 0.92$] (Figure 3). Post hoc Fisher LSD tests revealed that the post-imitation rearticulation rate was significantly higher than in the baseline condition [$p < 0.001$], suggesting the effective retention of this feature in subsequent non-imitative productions.

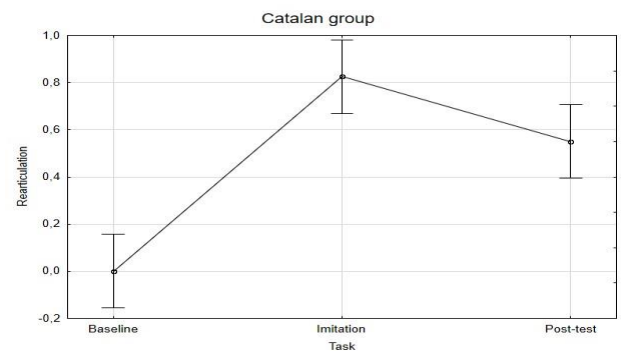


Figure 3: Rearticulation rate in the three tasks (baseline, imitation, post-test) in Catalan speakers' productions.

The speakers of Polish had a mean rearticulation rate of 0.56 ($SE = 0.12$) in the baseline condition. There was an increase to 0.81 ($SE = 0.08$) in imitation, followed by the mean of 0.66 ($SE = 0.11$) in the post-test non-imitative productions. The main task effect was also significant in this group [$F(2, 18) = 4.3$, $p = 0.03$, $\eta_p^2 = 0.32$] (Figure 4). The post-hoc tests showed that the rate difference between the baseline task and the post-test task was not statistically significant [$p = 0.5$].

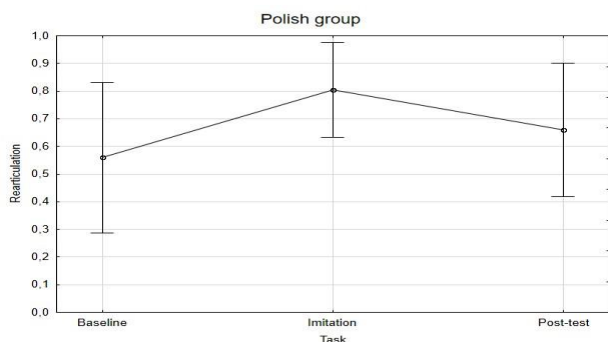


Figure 4: Rearticulation rate in the three tasks (baseline, imitation, post-test) in Polish speakers' productions.

The interaction model showed that the task type interacted significantly with the language group in their effect on the rearticulation rate [$F(2, 54) = 5.67$, $p = 0.006$, $\eta_p^2 = 0.17$] (Figure 5). The post-hoc tests revealed that the interaction was mainly contributed to by a significant difference between Catalan and Polish speakers in the baseline task (Catalan: $M = 0$; Polish $M = 0.56$; $p < 0.001$). There was no significant difference between Catalan and Polish speakers for either imitation (Catalan: $M = 0.83$; Polish: $M = 0.81$; $p = 0.88$) or post-test (Catalan: $M = 0.55$; Polish: $M = 0.66$; $p = 0.39$).

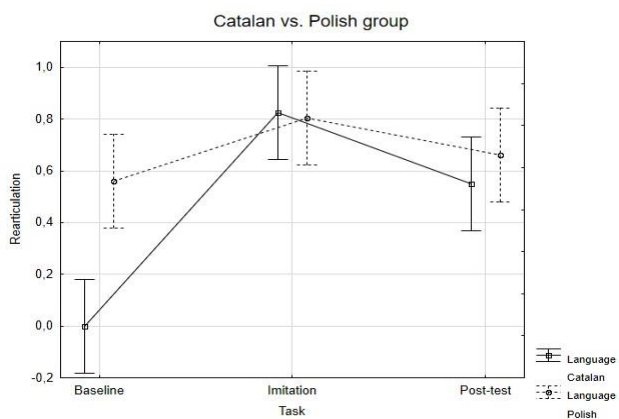


Figure 4: Interaction between task and language. Catalan speakers: solid line, Polish speakers: dotted line.

5. DISCUSSION

The analysis of the results allows us to address the formulated research questions.

What is the magnitude of imitation of rearticulation by speakers of Catalan?

The magnitude of imitation of rearticulation in Polish geminates by speakers of Catalan is high, at the rate of 0.83. It suggests that the Catalan speakers detected this feature and implemented it in their shadowed productions. Such a high rate implies that rearticulation is a psychoacoustically robust feature

and may be very effectively imitated even by speakers of the language that has only single-articulated geminates.

How does the imitative performance of Catalan speakers compare to the one by native speakers of Polish?

The performance of Catalan and Polish speakers is very similar with the imitation rate of 0.83 for the former and 0.81 for the latter group. It suggests that rearticulation is effectively imitated independent of whether or not it is implemented in the native language.

What is the magnitude of post-imitative retention of rearticulation in subsequent non-imitative productions?

The retention of rearticulated productions is high with more than half of the rearticulated non-imitative productions. It is especially evident in the Catalan speakers who never produced rearticulated geminates in the baseline task and had a rearticulation rate of 0.55 in the post-imitation productions. Not only was this feature robust in direct imitation but it was also encoded and stored in later productions, suggesting that phonetic imitation might facilitate learning of L2 sounds that do not have an equivalent in the L1.

The rearticulation rates obtained by the Catalan speakers are in line with previous studies exploring phonetic convergence in non-interactive settings [19, 20, 21]. However, the possibility exists that speakers converged on rearticulation while diverging on other dimensions such as VOT or closure durations.

Phonetic convergence has been hypothesized to work as an implicit and automatic mechanism [9]. In non-interactive settings, it involves low-level cognitive processes that prompt the listener to imitate the model speaker. Future research should address whether the same behaviour will transfer to conversational interactions.

Finally, the results reflect the cognitive processes connecting speech perception and production skills in L2 learning, in so far as the Catalan listeners were able to perceive the articulatory gestures of the Polish stops, which were primed during the shadowing and retention tasks.

5. CONCLUSIONS

This study on phonetic imitation of Polish rearticulated geminates by speakers of Catalan showed that:

1. Rearticulation in Polish was very effectively imitated by speakers of Catalan.

2. Rearticulation was retained in more than half of the Catalan speakers' post-imitative productions.
3. There were no significant differences in imitation and post-imitation productions between speakers of Catalan and control native speakers of Polish.

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