THE PERCEPTION OF A SECONDARY PALATALIZATION CONTRAST:
A PRELIMINARY COMPARISON OF RUSSIAN AND IRISH*

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The typology of secondary palatalization contrasts reveals certain asymmetries (Kochetov 2002; Takatori 1997), e.g. a contrast in coda position implies one in onset position, and a contrast in labials implies one in coronals. This paper presents results from a perceptual study of Irish and Russian that addresses the positional asymmetry in relation to labial stops and fricatives and provides further support for the hypothesis that a palatalization contrast in coda or word-final position is disfavored for perceptual reasons. The study, which tests both Russian and Irish listeners on both Russian and Irish productions using the same methodology, allows a direct comparison of the results for the two languages.
Keywords: palatalization, perception, Irish, Russian

1. Introduction

The typology of secondary palatalization contrasts reveals certain asymmetries (Kochetov 2002; Takatori 1997). For example, a contrast in coda position implies one in onset position, and a contrast in labials implies one in coronals. It is reasonable to think that these asymmetries may have a basis in the production and/or perception of a secondary palatalization contrast. However, there have been very few studies designed to address this hypothesis, and their results are not always consistent with each other. This paper reports on a perceptual study, employing an AX discrimination task, addressing the question with respect to onset vs. coda position. It represents a significant contribution in several respects. First, the study is conducted using listeners of both (Connemara) Irish and (Contemporary Standard) Russian, listening to the same set of controlled stimuli produced by both Russian and Irish speakers. This novel design allows us to directly compare results across the two languages. Second, it employs three speakers of each language to provide the stimuli for the discrimination task, allowing for more confidence in the results and generalizability. Finally, it compares the palatalization contrast in stops to that in fricatives (in addition to that in onset vs. coda), a comparison that has not been made before.

Russian and Irish differ in an important way. Unlike Russian, Irish is a minority and, arguably, an endangered language. Recent literature discussed below suggests that even in areas where Irish is spoken as a community language, young speakers are becoming more English-dominant. The Irish secondary palatalization contrast, a fundamental feature of Irish phonology, has generally seemed stable in the sense that speakers produce the contrast. However, our study provides some reason for possible concern. We find that our Russian listeners perceived a palatalization contrast more accurately than our Irish listeners, and that this was true whether the contrast was produced by Russian speakers or Irish speakers. In addition, our Russian stimuli were more accurately perceived whether the listeners were Russian or Irish. Though we must be

* We are grateful to audiences at the 8th Celtic Linguistics Conference (CLC8), the Palatalization Conference at the University of Tromsø, and the Linguistics Departments at Stanford University, UC San Diego, and UC Santa Cruz for comments and discussion. We are also grateful to Dhyana Buckley for her helpful review of this paper.

cautious when inferring anything about the state of the Irish language from a limited set of speakers, one possible conclusion is that the Irish palatalization contrast is showing subphonemic signs of instability. Another reason for caution in interpreting the results reported on here is that they involve the palatalization contrast only for the labial consonants [p] and [f].

2. Background

Unlike Russian, a dominant language having many millions of speakers, Irish is a minority language that could be regarded as endangered and that is spoken as a community language or on a daily basis by only tens of thousands of people according to the 2016 census (Central Statistics Office 2017). A recent study of children ages 7-11 who live in parts of Connemara where Irish is a community language, found that even there many children were English dominant in various measures, including (in a limited domain) phonetic accuracy (Péterváry et al. 2015). Loss of phonemic contrast, such as the palatalization contrast fundamental to the language, would be of more serious concern than phonetic accuracy, and such loss is not generally observed. However, phonetic accuracy potentially bears on contrast, and impressionistic reports of contrast may actually tell us little about the stability of the phonetic system. This is a point we return to in the conclusion.

(1) shows the phoneme inventory of Irish as spoken in Connemara, a dialect of Connacht Irish spoken largely west of Galway, while 0 shows that of Contemporary Standard Russian. As can be seen, the languages have in common a secondary palatalization contrast that pervades the phonemic inventory. The contrast exists in both onset and coda position in both Irish and Russian. In addition, various grammatical distinctions, often in coda position, rely solely on this contrast, e.g. Irish /bɔ:d/ 'boat' vs. /bɔ:dʲ/ 'boat (pl.)', and Russian /govorit/ 'speak (3rd sg.)' vs. /govoritʲ/ 'speak (inf.)'. (For more on Irish phonology and palatalization, see Ní Chasaide 1990; Ní Chasaide 1995.)

(1) Irish phoneme inventory

	Labial	Coronal	Dorsal	Glottal
Stop	p p^j	t t^j	k k^j	
	b b^j	d d^j	g g^j	
Fricative	f f^j	s s^j	x x^j	h (h^j)
	v v^j		(ɣ) ($ɣ^j$)	
Nasal	m m^j	n n^j	ŋ $ŋ^j$	
Liquid		l l^j		
		r r^j		

Russian phoneme inventory

	Labial	Coronal	Dorsal
Stop	p p^j	t t^j	k k^j
	b b^j	d d^j	g g^j
Fricative	f f^j	s s^j ʂ ʃː	x x^j
	v v^j	z ʐ	
Affricate		ʦ ʧ^j	
Nasal	m m^j	n n^j	
Liquid		l l^j	
		r r^j	

These properties make both Irish and Russian ideal for testing for a relationship between the implicational generalization onset > coda for a palatalization contrast and phonetic factors like the discriminability of the contrast in onset vs. coda position. For example, if speakers of Russian or Irish discriminate the contrast more poorly in coda position compared to onset, even though the contrast is robust in both positions, this would support a hypothesized perceptual basis for this typological asymmetry. If a contrast is more poorly discriminated in coda position, this might lead to the erosion of the contrast in that position over historical time, explaining why some languages, including Slavic languages related to Russian, lost the contrast in coda position where it had previously existed.

Kochetov (2004; 2006) examined the relative perceptibility of the Russian palatalization contrast in [p] vs. [t], in onset vs. coda position (using nonsense forms like [ta] and [ap^j]), employing an identification task. He found that listeners identified forms more accurately in onset compared to coda position, and for coronals compared to labials, a result that mirrors the typology. Using a discrimination task, Ní Chiosáin and Padgett (2012) found that Irish listeners likewise performed more accurately on the contrast in onset position compared to coda position. However, they also found that listeners more accurately discriminated the contrast in labials compared to coronals, contrary to the prediction that discriminability will mirror the typology.

Both of the above studies are limited in the sense that they made use of stimuli produced by only one speaker, a fact that severely limits our ability to generalize the results to the language at large. In addition, their methods differed in several ways. For example, Kochetov's study involved an identification task while that of Ní Chiosáin and Padgett employed a discrimination task; the consonants in Russian were voiceless unaspirated while those of Irish were voiceless aspirated and voiced unaspirated. Given these limitations and differences, what do we make of contradictory results like those seen above for labials vs. coronals in Russian vs. Irish? Do these reflect a real difference between the languages or are they artifacts of different experimental methods, or even of the use of a single speaker to produce experimental stimuli?

The study described here provides a comparison between Russian and Irish using the very same experimental methodology and the very same stimuli produced by both Russian and Irish speakers. It employs three speakers of each language to provide the stimuli. As a separate contribution, this study also compares the perception of the palatalization contrast in stops vs. fricatives, something that has not been done before. Does the onset vs. coda perceptual asymmetry seen in earlier experiments obtain for fricatives too? The typological generalization that a coda palatalization contrast implies an onset one applies to fricatives too, so the prediction

is that the fricatives should pattern like stops in this respect. Apart from this question, does the manner difference itself matter to the perception of palatalization?

The study described below manipulated position (onset vs. coda), place of articulation (labial vs. coronal), and manner (stop vs. fricative). However, the results presented in this paper focus only on the position and manner differences and are limited to the labial place of articulation.

3. Experimental methods

3.1 Participants

Three Irish speakers and three Russian speakers, all female, recorded the stimuli used for the perception experiment. The Russian speakers were students of Lomonosov Moscow State University, 18-19 years of age, who had lived their entire lives in Moscow or the Moscow area. The Irish speakers, aged 22, 30, 46, lived in the Connemara Gaeltacht up until their college years.[1] All three lived in the greater Dublin area since their early twenties and were all employed in the Irish medium education sector. All continue to use Irish on a daily basis. None of our speakers reported any difficulties with hearing or speaking. All volunteered for the experiment.

For the perception experiment itself there were 18 Russian participants and 15 Irish participants, who we will henceforth call 'listeners'. All Russian listeners were students of Lomonosov Moscow State University who volunteered for the experiment. All were between 17 and 23 years of age, except for three participants who were 29, 31, and 55 (average = 23). Most were the equivalent of undergraduate students in the U.S. system, but four were post-graduate students. All but three of the participants were female, reflecting a gender imbalance of the department from which they were recruited. Of the 18 participants, 10 had lived their entire lives in Moscow. The regions where the rest had lived are described in Figure 1. None reported any difficulties with hearing or speaking.

Subject	Regions - Ages
6	Tashkent, Uzbekistan, until 14, Tula, Russia, until 18, Moscow until 55
9	Denmark 23-25, otherwise Moscow until 29
10	Pskov, Russia, until 17, Moscow until 18
11	Tiraspol, Moldova, until 10, Moscow until 17
13	Tartarstan Region until 17, Moscow until 22
14	Volgograd Region until 9, Moscow until 19
15	Kovrov (Vladimir Region) until 17, Moscow until 19
17	Nizhny Novgorod, Russia, until 17, Moscow until 19

Figure 1: Areas lived in (and ages) of 8 of the Russian listeners.

The Irish participants, who volunteered for the experiment, were students pursuing their studies through the medium of Irish in Acadamh na hOllscolaíochta[2], National University of Ireland, Galway. Participants were aged between 19 and 47 (10 were between 19 and 29 (average=23), 5 were between 39 and 47). Ten were undergraduate students, and five were postgraduate students. All but three of the participants were female. Eight of the younger participants and one of the older participants lived all their lives in various townlands in the Connemara Gaeltacht, along with two of the older participants who spent one year and eight years, respectively, in English

[1] One speaker lived with her family in London from age 4-9, returning to Connemara until she went to college at 20.
[2] 'academy of university education'

speaking countries in their 20s. A further two of the younger participants spent nine and ten years, respectively, in England, while a further older participant, whose parents were native Irish speakers from Connemara, spent the first 14 years of her life in England. The last participant lived in Connemara until her teenage years before going to an English medium boarding school. She moved back to Connemara shortly after finishing her degree and was settled there for over 20 years. Twelve of the participants spoke mostly Irish at home; a further two whose mothers were not native Irish speakers spoke Irish and English, and English, respectively, at home. The final speaker, who returned from the UK aged 9, spoke English at home. All participants regardless of language background were very competent, natural speakers.

3.2 Materials

Since it was impossible to construct the controlled materials we wanted out of familiar words occurring in both Irish and Russian, we opted to use nonce forms. Figure 2 shows the forms aimed for in both languages (for the full experiment, only some of which is analyzed here), rendered in broad IPA transcription. Target consonants (underlined) were voiceless obstruents. As can be seen, we varied palatalization (palatalized vs. velarized), place of articulation (labial vs. coronal), manner (stop vs. fricative), and position (syllable/word onset vs. coda). The non-target consonant (on the opposite side of the vowel) was always velar [k] (if onset) or [x] (if coda), thus differing in place of articulation from the target consonant. We used non-target [x] in coda position because words of the desired shape ending in [k] are rare in Irish and strike speakers as odd. For consistency we transcribe non-palatalized target consonants as velarized, though velarization is less evident than palatalization in the context of back vowels.[3]

	Onset				Coda			
	Labial		Coronal		Labial		Coronal	
Stop	pʲax peách пях	pˠax pách пах	tʲax teách тях	tˠax tách тах	kapʲ cáip капь	kapˠ cáp кап	katʲ cáit кать	katˠ cát кат
Fricative	fʲax feách фях	fˠax fách фах	sʲax seách сях	sˠax sách сах	kafʲ cáif кафь	kafˠ cáf каф	kasʲ cáis кась	kasˠ cás кас

Figure 2: Nonce forms used. In each cell, first row is broad IPA transcription, second and third rows are the Irish and Russian spelling used in production elicitation. Target consonant is underlined.

While the broad transcriptions in Figure 2 convey the Russian pronunciations well, the Irish forms depart from these transcriptions in three significant ways (see Ní Chiosáin & Padgett 2012 for relevant discussion of the Irish facts). First, the vowel was generally longer in the Irish stimuli. Irish distinguishes short and long vowels; we chose the long low vowel, because the quality of short vowels in Irish depends greatly on the palatalization of surrounding consonants, something that would have undermined the comparability of the Russian and Irish materials.[4] Second, the realization of the long low vowel in Irish is [ɔː], not [aː]. Third, palatalized /sʲ/ is realized as [ʃ] or [ɕ] in Irish.

[3] We don't transcribe velarization in the non-target velars. The palatalization/velarization contrast in velars is marginal in Russian.

[4] The quality of non-low short vowels in Irish is *entirely* dependent on the neighboring consonants' palatalization, making collection of comparable materials with Russian impossible. Though they do not feature in this experiment, our recorded stimuli include the high vowels /i/ and /u/ as well.

Our materials are (mostly) nonce forms, for the purposes of control, but they are sequences of sounds that should cause little trouble for our speakers or listeners. In the case of Russian, two of the stimuli happen to be occurring words ([pax] 'groin' and [kap] 'wart, nodule'). Most of the rest occur not as words but as stressed syllables in longer words, e.g. [kat] in [ʁdvɐˈkat] 'lawyer', [tʲax] in [puˈtʲax] 'way (loc.pl.)'. Four stimuli are an exception to this: the subsequences [fʲax], [sʲax], [kapʲ], and [kafʲ] do not occur in the corpus described in Sharoff (2008) of word forms having a frequency of at least one occurrence per million. Regarding the first two, other stressed syllables of the form *Cʲax* are common (where *Cʲ* is any palatalized consonant), and stressed syllables of the form *fʲak* and *sʲak* occur in [tʲuˈfʲak] 'bed, mattress' and [tak i sʲak] 'this way or that'. Regarding the last two, stressed syllables of the form *kaC* are very common and a stressed syllable of the form *Cafʲ* occurs in [prʲɪtˈstafʲ] 'present (imper.)'. While syllables of the form *Capʲ* do not occur, other forms have palatalized labials following [a], e.g. [prʲɪtˈstafʲ] 'present (imper.)', or other vowels before [pʲ], e.g., [topʲ] 'swamp'. Our three Russian speakers appeared to have no unusual difficulty producing any of these forms.

In the case of Irish, five of the stimuli happen to be occurring words ([kɔːtʲ] 'Cáit (a name)', [sɔːx] 'well-fed, satisfied', [kɔːʃʲ] 'cheese', [kɔːs] 'case', and [fɔːx] 'in favour (of)'). All but the last are very familiar and would be frequent. In the case of [fɔːx], stressed syllables of the form *fɔːC* occur relatively frequently in other words, e.g., [fɔːs] 'growth'. As for the other nonce forms, where the target consonant is initial, the relevant *Cɔː* sequence occurs in another *CɔːC* word, e.g., [pʲɔːn] 'pen', [pɔːn] 'pawnshop, [tʲɔːn] 'tight', [tɔːl] 'yield', [fʲɔːl] 'deceit', [ʃʲɔːn] 'Seán (a name)'. The initial *Cɔː* in all cases also occurs in longer *CɔːCVX* forms. Where the target consonant is final, two possible forms arise: since the initial syllable is stressed in Irish[5], the target consonant is unquestionably syllabified with the preceding vowel only in monosyllabic forms, e.g. [stɔːt] 'state' and [rɔːp] 'confusion'. The remaining sequences occur in words where the consonant in question is intervocalic, in which case its syllable affiliation is less clear (Ní Chiosáin et al. 2012), e.g. [ˈkɔːpʲeːʃʲ] 'document', [ˈɔːfʲeːʃʲ] 'nonsense', [ˈɔːfəx] 'however'. The three Irish speakers were not as comfortable with the nonce reading task as the Russian speakers were, and they had to repeat occasional forms, but no words seemed to cause special difficulty.

The words were produced in the carrier phrase [skɐˈʒʸitʲɪ ___] 'Say ___' (Russian) or [ˈdʲeːrhə mɛ ___] 'say-FUT I ___' (Irish). Speakers were asked to speak naturally (as if to a friend), with no pause between the words, to place the stress on the target word, and to repeat any word if they felt they had made a mistake. Before recording they read out loud through the list of words, and we clarified the intended pronunciation if speakers produced the wrong phonemes (e.g., producing a velarized instead of palatalized sound). Words were presented in randomized order on a computer screen, along with the carrier phrase, and speakers read each phrase twice when it appeared. The presentation was blocked so that words with initial target consonants came first and words with final ones came second. This order of blocks was then repeated, so that there were four recorded tokens of each word in all. The recorded material included additional target words and sentence frame conditions not used for the experiment described here.

For all Russian speakers and one Irish speaker, recordings were made using a MicroTrack 24/96 recorder set to 41 KHz and 16-bit and a Shure WH20XLR headset dynamic cardioid microphone. A Marantz PMD670 recorder at 22 KHz and a Shure SM104 headset dynamic cardioid microphone were used for two of the Irish speakers. The Russian recordings were made

[5] This is true of the dialects in question with the exception of a small number of words (e.g. inniu 'today'. inné 'yesterday, anseo 'here'). Stress shift to a heavy syllable applies only in the southern dialects.

in a quiet room at Lomonosov Moscow State University, and the Irish recordings were made in separate locations for each speaker: in a quiet room in a home, in a school, and in a recording studio.

Words were extracted from carrier phrases for use in the discrimination experiment. The words were extracted so as to omit the velar non-targets from the words, meaning that the extracted sequences were nonsense CV and VC syllables like *at*, *f̈a*, etc. This removed a potentially distracting irrelevant consonant, and it shortened the time that syllables must be held in short term memory for the purposes of discrimination. To remove initial non-target [k], words were extracted starting at the point where the second and higher formants of the vowel became high in energy; if there was still an impression of an initial [k], this boundary was moved to the right until no such impression was left. To remove final non-target [x], words were extracted up to the point where the vowel periodicity of the waveform ceased. As for the target consonants, we judged their beginning or end based on information in the waveform and spectrogram; for initial stops we did not include the voiceless portion prior to the audible release; for final stops the audible release was included.

As noted above, during each trial the speakers produced each phrase twice. As a rule we extracted the second repetition within each trial for the perception experiment. Since there were two trials per stimulus word, this resulted in two recordings of each word (for each speaker and language) for the perception experiment. For all speakers but Irish Speaker 2, we extracted the first repetition only when the second was anomalous (due to hesitation, microphone pops, or the like). For Irish Speaker 2 we generally extracted the first repetition within each trial, because her second repetition word-final velar fricatives were unusually elongated.

The stimuli from Russian Speakers 1-3 and Irish Speaker 1 were downsampled to 22050 Hz to match the sampling rate for Irish Speakers 2-3 (who were recorded using different equipment). All of the stimuli were roughly normalized in intensity using the ‘scale peak’ feature of Praat (set to 0.8).

3.3 Perception experiment procedures

The perception experiment was presented using Superlab version 4 on an Apple laptop computer. It was conducted in a quiet room at Acadamh na hOllscolaíochta, National University of Ireland, Galway, located in An Cheathrú Rua (Carraroe) in Conamara (Irish) or at Lomonosov Moscow State University (Russian). The listeners wore headphones and received instructions via Superlab slides; these are given in full in the Appendix. All participants were volunteers.

As seen above, three properties of the stimuli were manipulated for this experiment, schematized in Figure 3 below. In the full experiment conducted, every trial was drawn from one of the eight cells in Figure 3. Since the results presented here are only for the labial consonants (unshaded in Figure 3), we focus on those. For each cell there were four kinds of trial, depending on the order of the stimuli and on whether the target consonants were the same or different in palatalization. For example, there were four kinds of trial involving initial /p/: *pʲa-pʲa*, *pʲa-pˠa*, *pˠa-pˠa*, and *pˠa-pʲa*. The number of ‘same’ and ‘different’ trials was thus identical. For the ‘same’ trials, the paired forms were different recorded tokens.

	Onset		Coda	
	Labial	Coronal	Labial	Coronal
Stop	pax	tax	kap	kat
Fricative	fax	sax	kaf	kas

Figure 3: Three factors manipulated in the experiment: position, place of articulation, manner of articulation.

Given the four conditions examined in this paper, four trial types, and two repetitions (per speaker) of each stimulus in the experiment, there were 32 trials per speaker. Since there were three Russian and three Irish speakers, there were 192 trials all. The experiment was blocked by speaker, so that there were six blocks, presented in random order for each listener. Within each block the order of presentation of the 32 trial types was also random. Listeners were prompted with the option to take a break between blocks. The interstimulus interval was 100ms. For half of the listeners, the button for 'same' corresponded to the right hand; for the other half, this correspondence was reversed.

Both accuracy and reaction time were collected, though primarily accuracy is reported here. Reaction times were measured relative to the onset of the second of the paired stimuli. During the experiment, the listeners were prompted to respond more quickly every time their reaction time exceeded 600ms.

4. Results

Before analysis, all trials recording reaction times greater than 3000ms. were removed. This eliminated only 8 observations, about 0.3% of the data.

Figure 4 plots listener performance on stimuli produced by Irish speakers against that on stimuli produced by Russian speakers, for proportion correct (left) and reaction time (right). Points represent Irish and Russian listeners. We make several observations based on these plots. First, our listeners responded fundamentally similarly to the stimuli from both languages, whether native or not. We infer this from the correlations evident in the plots: better performance w.r.t. one language's stimuli tends to accompany better performance w.r.t. the other's stimuli. Taking proportion correct first, for both the Irish and Russian listeners the Pearson's correlation showed a large positive association between the two ($r(13)= 0.72$, $p<.01$, $r(16)=0.72$, $p<.001$ respectively).[6] In the case of reaction times, again there were strong positive correlations for both Irish and Russian listeners ($r(13)=0.77$, $p<.001$, $r(16)=0.73$, $p<.001$). If, for example, Irish listeners simply could not make sense of the Russian palatalization contrast because it is so different, we would not expect to see such correlations. This is important because the conclusions of this paper assume that listeners perceive and respond to a palatalization contrast even for stimuli that are not native to them.

[6] The Pearson test assumes a normal distribution, but just in the case of Russian listeners hearing Russian speakers the distribution is significant on the Shapiro-Wilk normality test, which means this assumption is not safe. However, even using the Spearman correlation test for the Russian listeners there is a large positive correlation ($\rho(16)=0.62$, $p<.01$). For reaction times, in the case of Irish listeners hearing Russian speakers the normality assumption is not safe. The Spearman correlation again shows a strong positive correlation ($\rho(13)=0.59$, $p<.05$).

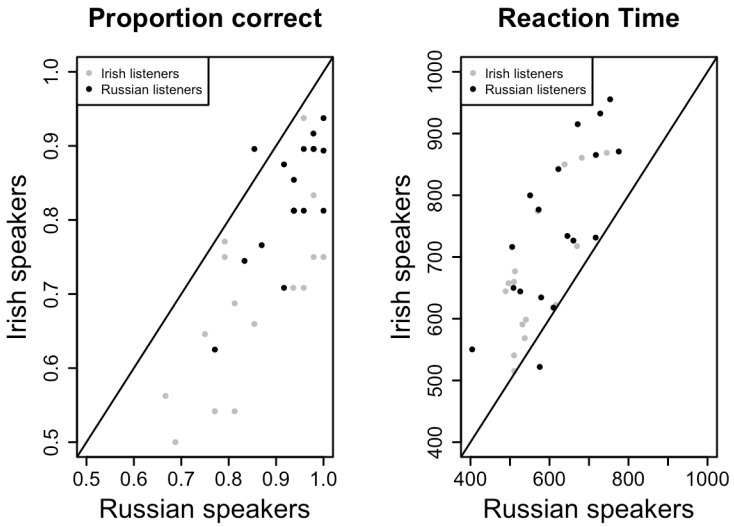

Figure 4: Performance of listeners hearing Irish stimuli plotted against that of listeners hearing Russian stimuli, for proportion correct (left) and RT (right).

The second observation we make based on these plots is that the Russian listeners were more accurate overall than the Irish listeners. This observation is based on the relative distribution of gray and black points in the left panel of Figure 4, with light gray points nearer to the lower left and black points nearer to the upper right of the figure. Finally and perhaps most surprisingly, all listeners – including Irish listeners – responded more accurately (left panel) and quickly (right panel) to stimuli produced by Russian speakers. If listeners had responded more successfully to stimuli from their own language, we would see the gray and black points separated by the line y=x.

These latter two observations can be seen more directly in Figure 5. The overall mean proportion correct was 0.88 for Russian listeners and 0.77 for Irish listeners (left panel). The overall proportion correct for listeners hearing Russian stimuli was 0.89 while that for those hearing Irish stimuli was 0.77. As the right panel shows, this advantage for Russian stimuli held across all speakers.

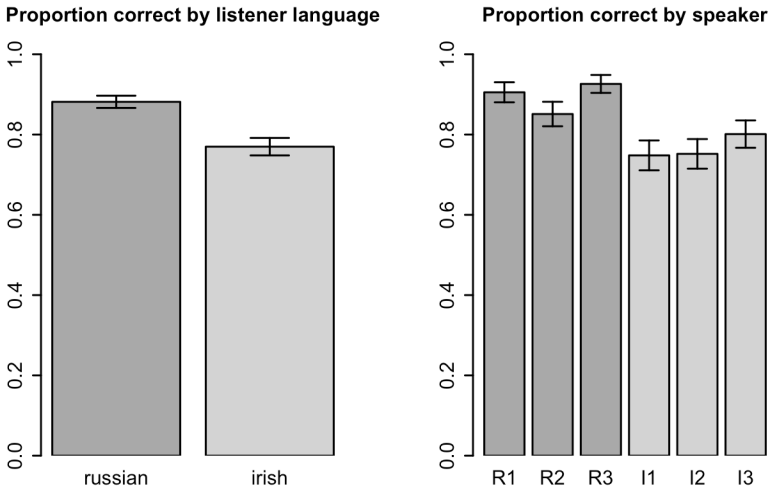

Figure 5: Overall proportion correct by listener language (left) and by speaker (right), for Russian (dark gray) and Irish (light gray) listeners and speakers.

Figure 6 shows overall proportion correct by syllable position (onset vs. coda) and manner of articulation (stop vs. fricative). Overall, accuracy appears to be greater for the palatalization contrast in onset position (mean=0.91) compared to coda (0.76). The contrast in stop consonants [p,t] had an overall advantage (mean=0.85) over that in fricatives [f,s] (0.81) as well, but this difference really only appears to hold in coda position.

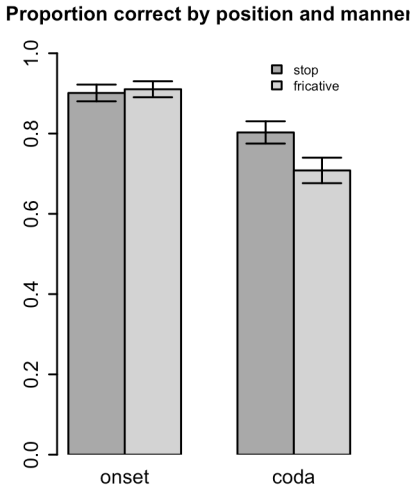

Figure 6: Proportion correct by syllable position and manner of articulation, for all listeners combined.

To better understand these effects it is helpful to break the data down further, where we can see important sub-patterns depending on the combination of listener language and speaker language. Figure 7 shows proportion correct by speaker language, for all combinations of position and manner. (For example, 'af' stands for the combination of coda and fricative conditions.) Dark gray bars represent Russian speakers and light gray bars Irish speakers. The left panel shows Russian listeners, the right panel Irish listeners. As can be seen, Russian listeners responded very accurately overall to Russian and Irish stimuli in onset position. However, in coda position Russian listeners responded less accurately to Irish stimuli, and this difference seems heightened in the case of fricatives. What is most remarkable is that Irish listeners (right panel) show a very similar pattern overall.

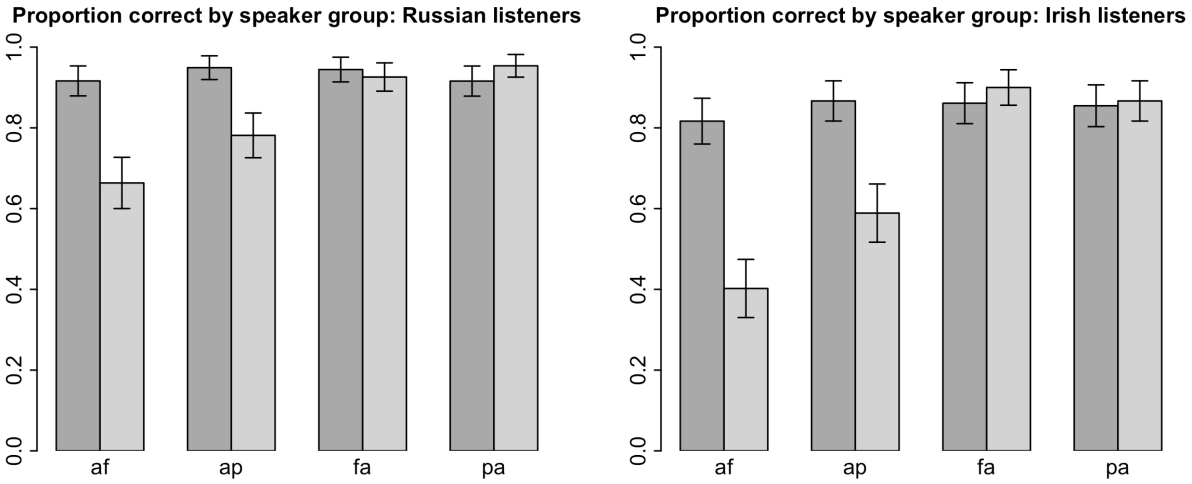

Figure 7: Proportion correct for all combinations of position and manner. On the left: Russian listeners hearing Russian speakers (dark gray) vs. Irish speakers (light gray). On the right: Irish listeners hearing Russian speakers (dark gray) vs. Irish speakers (light gray).

To test the observations above we ran a linear mixed effects logistic regression in R (R Core Team 2013) employing the *lme4* package (Baayen et al. 2008, Bates et al. 2012, Barr et al. 2013), with response (correct or incorrect) as the dependent variable and position (default=onset), manner (default=stop), speaker language (default=Russian), and listener language (default=Russian) as factors.[7] We included speaker and listener as random intercepts. (Models with random slopes did not converge.) Given the apparent interplay above between position and manner, we included this interaction in the model. The effect of position also seems to depend on the speaker group, so we also included this interaction. This last model was the best fit according to an ANOVA comparison (Baayen et al. 2008). No other interactions were pursued. The results of this analysis are shown in Table 1.

	b	*se*	*z*	*p*
Intercept	2.83	0.27	10.4	< 2e-16*
Position:coda	0.35	0.21	1.7	0.09
Manner:fricative	0.12	0.18	0.7	0.51
Listener_language:irish	-0.95	0.26	-3.7	0.0002*
Speaker_language:irish	0.19	0.27	0.7	0.48
Position x Manner	-0.77	0.22	-3.5	0.0005*
Position x Speaker_language	-2.04	0.23	-8.9	< 2e-16*

Table 1: Fixed effects in a logistic regression model of (in)correct responses

Focusing first on position and manner, this analysis reveals no significant main effects of these factors. Instead we see a significant position x manner interaction, reflecting poorer accuracy on the coda palatalization contrast particularly in the case of fricatives. In addition there is a significant position x speaker language interaction, driven by poorer accuracy w.r.t. coda contrasts when the stimuli are from Irish speakers. Finally, there is a significant main effect of listener language, reflecting poorer accuracy overall in the case of the Irish listeners.

[7] We are grateful to Jenny Bellik for assistance with this analysis.

5. Discussion and conclusion

The results of this perception study provide further support for the hypothesis that a palatalization contrast in coda or word-final position is disfavored for perceptual reasons. First, our listeners were less accurate in discriminating the palatalization contrast in the case of codas when the stimuli were from Irish speakers. Second, they were less accurate particularly in the case of coda [f], whether the stimuli were Irish or Russian. This finding of a perceptual vulnerability for the contrast in coda position jibes with that of Kochetov (2002) and Ní Chiosáin and Padgett (2012), but it is based on a more robust dataset than was available to those previous analyses: three speakers of each language, 15 Irish listeners, and 18 Russian listeners.

Our results also suggest that the palatalization contrast in stops may have a perceptual advantage over that in fricatives, but we found this asymmetry only in coda position, as noted above. Such an asymmetry has not been observed before, and it will be interesting to explore in future research whether it generalizes to other stop-fricative pairs than [p-f], and whether this asymmetry is reflected in the typology of palatalization contrasts.

What is perhaps most interesting about this study is its unusual design: testing both Russian and Irish listeners on both Russian and Irish productions using the very same methodology. This design allows us to directly compare the results for the two languages. A striking finding is that both Russian and Irish listeners discriminate the palatalization contrast more accurately in the case of Russian stimuli, as seen in the position x speaker interaction in our results. To put it differently, this experiment provides direct evidence that our Irish speakers did not produce the coda palatalization contrast as successfully as did our Russian speakers, if 'success' is gauged by a listener's ability to discriminate the contrast. Nor did Irish *listeners* discriminate the contrast as successfully as did Russian listeners, even holding productions constant, as can be seen in the main effect of listener language we found. In this study, at least, those who spoke Russian were more proficient at both producing and perceiving the palatalization contrast.

What should we make of these findings? Obviously the Russian participants may have differed from the Irish participants in some way that can explain these differences without any bearing on the status of Irish generally. For example, though all of the participants were college students, the Russian participants were all students at Moscow State University, a very prestigious university. It is conceivable that they were more adept at the experimental tasks for reasons related to their level of education or socio-economic status. Though we cannot rule such an explanation out, our results may instead provide a new kind of experimental evidence that proficiency in Irish w.r.t. the palatalization contrast is vulnerable or unstable compared to that in Russian, an interpretation that is consistent with other research discussed in section 2. Though this may be a matter of 'phonetic accuracy' in the terminology of Pétervári et al. (2015), if it suggests a possible erosion of the Irish palatalization contrast that is in progress then it is obviously no mere matter of pronunciation. Rather, it bears on a fundamental structural property of Irish phonology. Of course, the results reported here are based only on the palatalization contrast borne by /f/ and /p/. It remains to be seen whether they generalize to other consonant types.[8]

[8] Independent research on the production of palatalization contrasts by a different group of speakers of Connemara Irish shows that labials display secondary palatalization and velarization tongue body gestures as robust as those at other places of articulation (Bennett et al. 2018). Thus although the current experiment focused on labials, the place of the consonant was not likely a critical factor when considering the robustness of the contrast for this group of listeners.

Appendix

I. Perception experiment instructions. Below are the Irish and Russian instructions that were presented to the perception experiment participants, and a rough English translation. (Phrases in '[]' brackets were omitted in Irish.) Slide transitions are indicated by '||'.

Perception experiment

Thank you for your participation in this experiment. Its goal is to help us understand how people perceive speech sounds. || [In this experiment], pairs of small invented "words" are presented. (These words may or may not resemble words of the Irish (Russian) language.) [After listening to each pair], you should decide whether they are the same "words" or not. || If the words seem the same to you, press the BLUE button on the button box. If the words sound different to you, press the RED button. || In the course of the experiment, you will receive information about whether you answered quickly enough. Please try to answer as accurately *and* quickly as possible. || When you are ready, put on the headphones, place your left and right hands on the corresponding colored buttons, and press one or the other button to begin.

Triail éisteachta

Go raibh maith agat as ucht páirt a ghlacadh sa triail seo. 'Sé aidhm na trialach ná cabhrú linn tuiscint a fháil ar an gcaoi a gcloiseann daoine fuaimeanna sa gcaint. || Séinnfidh an ríomhaire péirí 'focal'. (D'fhéadfadh go bhfuaimneodh na focail cosúil le focail Ghaeilge ach ní gá gur mar sin a bheadh.) Éist leis na focail agus socraigh an mar a chéile atá siad nó éagsúil. || Má shíleann tú gur mar a chéile atá siad, brú an cnaipe GORM ar an mbosca cnaipí. Má shíleann tú gur éagsúil atá siad brú an cnaipe DEARG ar an mbosca cnaipí. || I rith na trialach inseofar duit an bhfuil tú ag freagairt sách scioptha. Déan iarracht freagairt chomh cruinn *agus* chomh scioptha agus is féidir. || Nuair atá tú réidh, cuir ort na cluaisíní, cuir do lámh dheis agus do lámh chlé ar na cnaipí cuí, agus brú ceann de na cnaipí.

Эксперимент на восприятие

Спасибо за Ваше участие в этом эксперименте. Его цель – помочь нам понять, как люди воспринимают звуки речи. || В этом эксперименте предъявляются пары маленьких, придуманных «слов». (Эти слова могут или не могут походить на слова русского языка.) При прослушивании каждой пары, Вы должны решить, это – те же самые «слова» или нет. || Если слова кажутся Вам теми же самыми, нажмите ГОЛУБУЮ кнопку на коробочке с кнопками. Если слова кажутся Вам различными, нажмите КРАСНУЮ кнопку. || Во время эксперимента, Вы будете получать информацию, о том, ответили ли Вы достаточно быстро. Пожалуйста, старайтесь отвечать как можно правильно *И* быстро. || Когда готовы, наденьте наушники, положите левую и правую руки на соответсвующие цветные кнопки, и нажмите ту или другую кнопку чтобы начать.

References

Bennett, R., G. McGuire, M. Ní Chiosáin & J. Padgett, 2018. An ultrasound study of Connemara Irish palatalization and velarization. Journal of the International Phonetic Association 48, 261-304.

Central Statistics Office. 2017. Chapter 7: The Irish Language. Census 2016. Available at https://www.cso.ie/en/media/csoie/releasespublications/documents/population/2017/7._The_Irish_language.pdf.

Kochetov, A., 2002. Production, perception, and emergent phonotactic patterns. New York, Routledge.

Kochetov, A., 2004. Perception of place and secondary articulation contrasts in different syllable positions: language-particular and language-independent asymmetries. Language and speech 47.4, 351-382.

Kochetov, A., 2006. Testing licensing by cue: a case of Russian palatalized coronals. Phonetica 63, 113-148.

Ní Chasaide, A., 1990. A pilot study of articulatory and acoustic measurements of coarticulation in Irish (Gaelic). Esprit II/Basic Research Action No. 3279. Progress Report.

Ní Chasaide, A., 1995. Irish. Journal of the International Phonetic Association 25, 34-39.

Ní Chiosáin, M. & J. Padgett, 2012. An acoustic and perceptual study of Connemara Irish palatalization. Journal of the International Phonetic Association 42.2, 171-191.

Ní Chiosáin, M., P. Welby & R. Espesser, 2012. Is the syllabification of Irish a typological exception? An experimental study. Speech Communication 54, 68-91.

Péterváry, T., B. Ó Curnáin, C. Ó Giollagáin & J. Sheahan, 2015. Analysis of bilingual competence: language acquisition among young people in the Gaeltacht. Dublin, An Chomhairle um Oideachas Gaeltachta agus Gaelscolaíochta.

R Core Team, 2013. R: A language and environment for statistical computing (version 3.0.1). Vienna, R Foundation for Statistical Computing (retrieved from http://www.r-project.org/).

Sharoff, S., 2008. The frequency dictionary for Russian. Moscow, Russian Research Institute of Artificial Intelligence.

Takatori, Y., 1997. A study of constraint interaction in Slavic phonology. New Haven, Ph.D. dissertation, Yale University.