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The Effect of Orthography on the Lexical Encoding of Palatalized Consonants in L2 Russian

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Abstract

The current study investigated the potential facilitative or inhibiting effects of orthography on the lexical encoding of palatalized consonants in L2 Russian. We hypothesized that learners with stable knowledge of orthographic and metalinguistic representations of palatalized consonants would display more accurate lexical encoding of the plain/palatalized contrast. The participants of the study were 40 American learners of Russian. Ten Russian native speakers served as a control group. The materials of the study comprised 20 real words, familiar to the participants, with target coronal consonants alternating in word-final and intervocalic positions. The participants performed three tasks: written picture naming, metalinguistic, and auditory word–picture matching. Results showed that learners were not entirely familiar with the grapheme–phoneme correspondences in L2 Russian. Even though they spelled almost all of these familiar Russian words accurately, they were able to identify the plain/palatalized status of the target consonants in these words with about 80% accuracy on a metalinguistic task. The effect of orthography on the lexical encoding was found to be dependent on the syllable position of the target consonants. In intervocalic position, learners erroneously relied on vowels following the target consonants rather than the consonants themselves to encode words with plain/palatalized consonants. In word-final position, although learners possessed the orthographic and metalinguistic knowledge of the difference in the palatalization status of the target consonants—and hence had established some aspects of the lexical representations for the words—those representations appeared to lack in phonological granularity and detail, perhaps due to the lack of perceptual salience.

Keywords

bilingual mental lexicon, lexical encoding, L2 Russian, orthography, palatalization

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1 Introduction

When L2 learners start to acquire the orthography of another language, they have to master new grapheme–phoneme correspondences. In languages with transparent or shallow orthographies, the spelling–sound correspondences are relatively straightforward—for example, Italian or Spanish. In opaque or deep orthographies, the relationship between letters and the sounds that they are associated with is much more complicated and lacks transparency. L2 learners have to pay attention to the potential lack of congruency between auditory and visual-orthographic input, especially when learners' first language uses a transparent orthography. For instance, in English the same letter sequence <ea> can be pronounced as /i/ in <meat> and /e/ in <steak>. Another challenging task that L2 learners face is developing awareness of how congruent or incongruent grapheme–phoneme correspondences are in their native and second languages, when the two languages share similar graphemes or a similar writing system. For example, the grapheme <w> in Polish denotes the sound /v/ in <woda> /voda/ "water," whereas in English the grapheme <w> corresponds to a glide /w/ <water> /wɑɾɚ/. Moreover, learners should also know that even congruent phoneme–grapheme correspondences can be context-dependent. In English and French, the letter <t> represents the same phoneme /t/; however, word-finally in French it is not always realized; compare English <cat> /kæt/ and French <chat> /ʃa/ "cat." Orthographic incongruences between L1 and L2 can lead learners to establish inaccurate phonolexical representations for L2 words (e.g., Hayes-Harb, Nicol, & Barker, 2010). The goal of this study is to investigate whether orthographic knowledge in L2 fosters the formation of accurate lexical representations for a perceptually challenging phonological contrast. Specifically, we investigate the possible contribution of orthographic and metalinguistic knowledge to the lexical encoding of the plain/palatalized contrast in L2 learners of Russian.

2 The relationships between orthography, speech perception, production, and lexical encoding

In previous research, orthography has been found to affect different domains of L2 phonological development, such as perception, production, and lexical encoding (Bassetti & Atkinson, 2015; Escudero, 2015; Escudero & Wanrooij, 2010; Escudero, Hayes-Harb, & Mitterer, 2008; Hayes-Harb et al., 2010; Pytlyk, 2011; Showalter & Hayes-Harb, 2013, 2015; among others). The result of these interactions has been both positive and negative. Simon, Chambless, and Kickhöfel Alves (2010) investigated whether learners' exposure to orthographic representations had a facilitative effect on the acquisition of a new phonological contrast. The participants of their study were native speakers of American English without any formal instruction in French or German beyond high school. During the word-learning stage, they were assigned to one of two groups. The "sound only" group saw pictures of objects (e.g., a banana or a boat) that were associated with nonwords alternating in vowels /u/ and /y/, and heard pronunciation of those words (e.g., /dyʒ/ or /duʒ/). The "sound–spelling" group was additionally provided with the spelling of the words <dûge> or <douge>. Then the participants were tested on an AXB categorization task using new stimuli with the same contrast. They heard three novel words containing the vowels /u/ or /y/ and had to decide whether the second word that they heard was the same as the first one or the third one. Although the "sound–spelling" group performed better than the "sound only" group, the difference was not significant. Moreover, there was a lot of variation in the scores of the participants from the two groups. Thus, the availability of orthographic information did not seem to significantly contribute to better perceptual discrimination of a new phonological contrast. One of the explanations that the authors provided to explain the absence of a positive orthographic effect concerned the interference of the native orthography. Since English belongs to those languages with opaque orthographies, which lack one-to-one mappings of graphemes to phonemes, American English learners were not used to utilizing orthographic representations to the full extent that speakers with a transparent orthography might have.

Escudero and Wanrooij (2010) found evidence of how reliance on transparent orthography in the native language can facilitate perception of phonetic contrasts in L2. The participants of their study were beginning and advanced Spanish-speaking learners of Dutch, who were tested on their acquisition of the five Dutch contrasts /a/–/ɑ/, /i/–/ɪ/, /y/–/ʏ/, /i/–/y/, and /ɪ/–/ʏ/. The participants performed an XAB categorization task and an orthographic task, in which they heard vowel tokens and were asked to choose their answers from the orthographic representations of the 12 Dutch vowels. The results of the study showed no significant difference between beginners and advanced learners on the XAB task. Categorizing the contrast /a/–/ɑ/ was found to be the most difficult for both groups of learners. However, the results of the orthographic task showed that /a/ and /ɑ/ were identified significantly better than the other vowels. The authors explained this asymmetry by the fact that the corresponding orthographic representations of <aa> and <a> alerted learners to the durational cue that differentiates the contrast. Since Spanish orthography is transparent, Spanish-speaking learners might have decoded vowel quantity in Dutch using orthographic representations: <aa> was used for a longer sound, whereas <a> for a shorter sound. The same effect was not found for /y/–/ʏ/, which are represented in the Dutch orthography by <uu>–<u>. Unlike /a/–/ɑ/, the vowels /y/–/ʏ/ have spectral rather than durational differences. Therefore, it seems that orthography has a facilitative effect only when both auditory and orthographic information reinforce the same distinction.

In production, the effect of L2 orthography also seems to be tied to the depth of the native orthography. Similarities in the depth of orthographies have a facilitative effect on production, whereas differences in the depth of orthographies have an inhibitory effect. In addition, due to the incongruence between letter–sound correspondences in native and target languages, orthography can mislead learners in their production. The effect of native orthography and specifically the influence of its depth on nonnative speech were examined by Erdener and Burnham (2005). In their study, Turkish speakers, whose orthography is transparent, and Australian English speakers with an opaque orthography were tested on the production of Spanish (transparent) and Irish (opaque) nonwords. During the familiarization stage, the participants were exposed to words presented in four conditions: auditory-only (participants heard the words), auditory-visual (participants heard the words and saw the lower part of the speaker's face producing them), auditory-orthographic (participants heard the words and saw their spelling), and auditory-visual-orthographic (participants heard the words, saw the lower part of the speaker's face producing them, and saw the spelling of the words). During the testing phase, the participants performed a word-repetition task and a writing task in the orthographic conditions. The results showed that Turkish and Australian participants made fewest errors when spelling was provided (i.e., the orthographic conditions) and most errors in the auditory-only condition. Overall, Turkish participants made fewer phonetic errors than Australian English speakers in nonorthographic conditions. However, in orthographic conditions, performance was modulated by target language: Turkish participants outperformed Australians on the Spanish nonwords but made more errors than Australian English speakers on the Irish nonwords. The authors argue that Turkish participants had an advantage in Spanish because they were used to straightforward relationships between graphemes and phonemes in their native (transparent) orthography and they successfully transferred this approach to Spanish. However, this approach led to many additional mistakes when producing nonwords in Irish, which has an opaque orthography. Speakers of Australian English did not differ in their performance on Spanish and Irish nonwords. Since English has an opaque orthography, Australian participants were not used to taking advantage of the supplied spelling, which is why their performance on Spanish nonwords did not differ from their performance on Irish nonwords.

Grapheme–phoneme correspondences that differ in the native and second languages can also lead to the development of inaccurate phonolexical representations. Hayes-Harb et al. (2010) set out to examine what effect incongruent letter–sound mappings introduced by the native orthography could have on the phonological form of new words. The participants of the study were American English speakers who were assigned to one of three groups for a familiarization stage in which they learned nonwords. Participants in the “congruent orthography” group were only presented with the spelling of the nonwords that conformed to English. Participants in the “incongruent/congruent orthography” group were presented with both congruent nonwords and incongruent nonwords, which contained either a silent letter or an altered grapheme–phoneme correspondence. For example, the spelled forms were <kamand> and <faza>, whereas the respective spoken forms were /kɑməd/ and /fɑʃə/. The auditory group was exposed only to the pronunciation of target nonwords. Then all the groups performed an auditory word–picture matching task. The results showed that learners who were exposed to incongruent grapheme–phoneme correspondences experienced interference from their native orthography and performed worse than the participants in the “congruent orthography” group. Moreover, changing a letter–sound mapping (e.g., <z> for /ʃ/, which does not conform to English mappings) had a more detrimental effect on learners’ performance than adding a silent letter (e.g., <n> in the example <kamand>), perhaps due to wide use of silent letters in English.

Despite the interference of grapheme–phoneme incongruences between native and second languages, orthographic and metalinguistic knowledge together with explicit instruction have been found to assist learners in establishing separate lexical representations for difficult contrasts, especially if these contrasts are not well discriminated in perception (Cutler, Weber, & Otake, 2006; Escudero et al., 2008; Hayes-Harb & Masuda, 2008; Showalter & Hayes-Harb, 2013, 2015; Weber & Cutler, 2004). Escudero et al. (2008) examined whether orthography has a facilitative effect on establishing novel lexical contrasts. The participants of their study were highly proficient Dutch-English bilinguals who were asked to memorize English-sounding nonwords containing the vowels /ɛ/–/æ/, which are perceptually challenging for Dutch learners of English. One group of participants was exposed only to auditory forms during a word-learning stage, whereas the other group was exposed to both auditory and written forms. During the testing phase learners performed a four-way forced choice task using an eye-tracking paradigm. Learners who were exposed to auditory forms only exhibited symmetric competitor effects (measured as proportion of looks) when listening to the first syllable of a novel (target) word, which differed from its competitor only in terms of a perceptually challenging vowel contrast (e.g., <tenzer> /*tɛn*zə/ vs. <tandek> /*tæn*dək/). This suggests that lexical representations for the two items of a pair did not encode the /ɛ/–/æ/ contrast with different vowels. Rather, the symmetrical activation pattern suggests that the first syllable of both novel words was encoded as the same homophonous syllable /tɛn/ in the L2 lexicon. Learners who were exposed to both auditory and visual forms showed asymmetric lexical activation: /ɛ/ targets received more eye-fixations than /æ/. This asymmetrical activation pattern suggests that the /ɛ/–/æ/ contrast was encoded as separate representations at the lexical level as a result of orthographic exposure. Orthography seemed to have had a positive effect on differentiating between two categories and establishing a lexical contrast for novel words with a difficult alternation. However, Cutler (2015) cautions that creating lexical contrasts without perceptual support can result in more disadvantages than benefits. She argues that misperceiving and encoding minimal pairs as homophones does not create an unsurmountable problem for the language. For example, replacing /æ/ with /ɛ/ adds 137 homophones to the English lexicon, according to Cutler (2005). A much more serious problem arises by temporary overlap among words, which results in increased competition and processing delays for learners. In this case, not only minimal pairs compete but also words embedded in context. Cutler (2005) claims that 7090 spurious embeddings arise if /æ/ is confused with /ɛ/ (e.g., Broersma & Cutler, 2011).

The current study set out to examine the relationship between orthography and lexical encoding of Russian plain and palatalized consonants. This study differs from previous studies investigating the effects of orthography in several ways. First of all, the difference between plain and palatalized consonants is based on the secondary feature of articulation instead of the primary articulation researched in other studies. Second, the orthographic code for palatalization is located on the neighboring letter, which requires learners to acquire the necessary metalinguistic knowledge. Also, the current study used only words that were familiar to learners to ensure that participants had already encountered them in spoken and/or written input and established lexical representations for these words. Using real words was preferred over the use of novel forms that are usually acquired for the purposes of the experiment through a word-learning paradigm (e.g., Escudero et al., 2008; Hayes-Harb & Masuda, 2008) to avoid certain issues that surround the lexical encoding of new contrasts, such as how much time should pass for the learning of new words to consolidate and trigger strong lexical competition effects (Dumay & Gaskell, 2007). Moreover, studies that employ novel words or contrasts assume that the specific orthographic knowledge representing the word or the contrast is not present at the outset of the experiment. By exposing learners to novel orthographic representations or mappings, researchers determine whether the newly acquired knowledge of orthography has a spontaneous effect on word learning, examining interference from the L1, phoneme–grapheme congruency, etc. However, this short-term laboratory word learning is not quite representative of what happens in the real world with "real" learners. The novel word studies posit that once learners know the written form of words as a result of being exposed to it, and if that form is conducive to encoding the contrast, then learners' phonolexical encoding will be more accurate. Our study tests the assumption that there is a link between knowing the written form of words and the accuracy of the phonolexical representation for these words. It does so by actually measuring learners' current orthographic knowledge and assessing whether it is indeed related to the precision of the phonological form of learners' lexical representations for highly familiar words.

3 Palatalization in Russian

Palatalization, which is phonemic in the Russian language, is "the superimposition of a raising of the front of the tongue toward a position similar to that for /i/ on a primary gesture" (Ladefoged & Maddieson, 1996, p. 363). In contemporary Russian, there are 15 palatalized consonants that are paired with plain counterparts. They can occur in the word-initial, word-medial, and word-final positions, both before vowels and consonants—for example, palatalized /lʲ/ in the words *lʲod* – "ice," *bolʲˈnoj* – "sick," and *nolʲ* – "zero."[1] Palatalized and plain consonants (or soft and hard consonants in Russian linguistics) share the same graphemes in Russian, but palatalization is not opaque. Palatalized consonants are either followed by a letter called the "soft sign" <ь> or a special set of soft series letters <и>, <е>, <я>, <ё>, <ю>. Russian also has a corresponding set of hard series letters <ы>, <э>, <а>, <о>, <у> that occur after plain consonants. Thus, although the Russian vocalic system consists of only five vowel sounds /i/, /e/, /a/, /o/, /u/, it uses ten vowel letters specifically to represent plain and palatalized consonants. In this way, Russian orthography sets a spelling trap for uninformed learners and makes them believe that in minimal pairs like <лук> *luk* "onion (bow)" vs. <люк> *lʲuk* "manhole," the initial consonants are the same, whereas the subsequent vowels are different. In reality, however, it is vice versa: the initial consonants are different and the vowels are the same.[2]

The situation with orthographical representations is further complicated by inconsistencies observed in loanwords and a certain class of original Russian words. Consider the words <кафе> *kaˈfe* "cafe" and <кофе> *ˈkofʲe* "coffee." In the former word, /f/ is plain, whereas in the latter it is palatalized. However, in the spelling of both words, the fricative is followed by a soft series letter <е>. If the word *kaˈfe* had conformed to the Russian spelling system, it would have been written with a hard series vowel <э> after the plain /f/. Irregularities in orthography can also be found in original Russian words with sibilants, such as <шёпот> *ˈʃopot* "whisper" and <шорох> *ˈʃorox* "rustle." The initial sibilant is followed by a soft series letter <ё>, as well as <о> even though Russian /ʃ/ is always hard. Russian has numerous spelling rules that dictate whether a soft series or hard series vowel should be written after sibilants. These rules stem from the historical development of the Russian language (see Hamilton, 1980, for an overview of spelling rules).

Despite the fact that there is a lot of positive evidence in orthography to demonstrate that pronunciation of a consonant changes depending on the vowel that follows, there is also evidence that shows the opposite. Consonant articulation can stay the same even when followed by different vowels in spelling, or it can change when followed by the same vowel grapheme. As a result, such inconsistencies can interfere with the correct phonolexical encoding of words. This situation is made more difficult by the perceptual difficulties usually encountered by learners of L2 Russian whose L1 does not phonemically distinguish the plain/palatalized contrast (Diehm, 1998; Kochetov, 2002; Lukyanchenko & Gor, 2011; Rice, 2015). For example, in a study by Diehm (1998), American English learners of Russian were able to correctly identify only 73% of plain and palatalized consonants in intervocalic position (CV vs. CʲV) in a four-way forced choice identification task. Thus, learners who can neither perceive the difference between palatalized and plain consonants well nor identify them in orthography might erroneously encode minimal pairs, such as *luk* "onion (bow)"–*lʲuk* "manhole," as homophones in Russian. Learners who are familiar with metalinguistic rules and can identify palatalized consonants in orthography equip themselves with an additional tool that can help them in mastering the difficult Russian contrasts and establishing accurate lexical representations, especially in the absence of robust perceptual support.

The fact that palatalization poses a serious challenge for learners has been demonstrated not only in perception studies but also in production (Bolanos, 2013; Diehm, 1998; Hacking, 2011; Hacking, Smith, Nissen, & Allen, 2016). In a recent study, Hacking et al. (2016) provided electropalatographic and acoustic analyses of the palatalized and plain consonants in coda position as produced by advanced American English learners and Russian native speakers. Each participant had a dental mold taken of their palate that was used to construct individual pseudopalates containing 124 electrodes. The measurements taken from the electrodes showed that Russian native speakers contacted many more posterior electrodes (corresponding to the palatal place of articulation) when producing palatalized consonants than did American learners, 45% versus 22% respectively. For the acoustic analysis, Hacking et al. measured F2s of the vowels, one of the most salient cues, preceding palatalized and plain consonants. The F2s of the vowels produced by American learners before palatalized consonants were similar to the F2s for vowels preceding plain consonants produced by the Russian native speakers. These findings suggest that American learners did not realize the most important gestures necessary for the production of palatalization (i.e., the tongue should be bunched up and moved toward the hard palate) and, as a result, produced palatalized consonants very similarly to their plain counterparts.

Research on the phonolexical encoding of Russian palatalization by L2 learners is scarce. To the best of our knowledge, there are only two studies that looked at the phonological representations of words with palatalized consonants in L2 Russian (Chrabaszcz & Gor, 2014; Gor, 2014). Gor (2014) investigated phonological processing by heritage speakers and L2 learners of Russian as part of a bigger project on the perception of speech in noise. The participants were divided into high- and low-proficiency groups using the Interagency Language Roundtable (ILR) testing format. The low-proficiency group had ILR oral proficiency levels from 1 to 2 (intermediate to advanced). The high-proficiency group had ratings of 2+ (advanced high) and above. The participants were asked to perform a picture–word discrimination task. The stimulus materials for the task were Russian minimal pairs with /t/–/tʲ/ and /p/–/pʲ/ word-finally, as well as other pairs of consonants in a prevocalic condition /CʲV/–/CjV/. Participants heard one word from the minimal pair and saw two pictures associated with the minimal pair on the screen. They had to decide which picture matched the word they heard. Results showed that Russian native speakers and high-proficiency heritage speakers of Russian behaved very similarly, with 99% and 98% correct matches respectively. Low-proficiency heritage speakers performed similarly to high-proficiency L2 learners, 79% and 76% correct respectively. Low-proficiency L2 learners obtained an accuracy rate of 60%, which suggests that these learners did not have stable representations for words with palatalized consonants even though their performance was somewhat better than at chance.

In another study, Chrabaszcz and Gor (2014) examined the effects of semantic, morphological, and syntactic context on the processing of phonolexical ambiguity at the sentence level. The participants of the study were native speakers of Russian and American learners of Russian. They were asked to perform a listening comprehension task with word identification and a high-variability AX task with /l/–/lʲ/, /t/–/tʲ/, and /f/–/fʲ/ in word-final position. Overall, learners' performance in the AX task was significantly worse than that of Russian native speakers. The effect of consonant contrasts was statistically significant for learners but not for Russian native speakers. The /l/–/lʲ/ contrast was the easiest for learners, /t/–/tʲ/ occupied the intermediate position, and /f/–/fʲ/ was the most challenging. In the listening comprehension task, the participants were presented with two types of sentences. In congruent sentences, the target word matched the context—for example, *My younger brother and elder* ***sister*** *are coming to see me tomorrow*. In incongruent sentences, there was a mismatch of a specific type, such as semantic ("sister"/"system"), morphological ("seen"/"sees"), or syntactic ("seam"/"seize"), for example, *My younger brother and elder* ****system*** *are coming to see me tomorrow*. After the participants heard a sentence, they had to decide which of the two words presented on the computer screen occurred in the sentences they had just heard. In the critical test condition, the target words were minimal pairs that differed in the palatalization status of a word-final consonant—for instance: (congruent condition) *A little boy drew a straight* ***angle (ugol)*** *in his geometry notebook*; (incongruent condition) *A little boy drew a straight* ****coal (*ugolʲ)*** *in his geometry notebook*. Results showed that unlike native speakers, L2 learners' error rate reached 40% in congruent sentences and approximately 60% in incongruent sentences. Chrabaszcz and Gor interpreted such results as evidence of the fuzziness of their phonolexical representations. L2 learners did not solely refer to the sentence context to resolve ambiguities, but seemed to rely on their phonolexical representations when identifying the words. If learners had relied on the context alone, their error rate would likely have been very low in congruent sentences and very high in incongruent sentences, which was not reflected in the results.

The findings of these two studies suggest that American English learners of Russian do not establish accurate lexical representations of words with palatalized consonants. The contrast between plain and palatalized consonants seems to pose so much difficulty that even low-proficiency heritage speakers, who have continually been exposed to Russian since birth, did not perform equally to Russian native speakers.

4 The current study

The reason why L2 learners of Russian struggle with the lexical encoding of words with the plain/palatalized contrast might stem from a lack of sufficient perceptual abilities to reliably differentiate palatalized from plain consonants, especially in word-final position. However, these difficulties could also be the result of orthographic interference since by employing the same graphemes for plain and palatalized consonants, orthography might mislead learners in their formation of phonolexical representations. No study to date has investigated the effects of orthography on the lexical encoding of palatalized consonants in L2 Russian. Thus, the current study seeks to fill this gap by exploring the following research questions:

1. Do American English learners of Russian possess orthographic and metalinguistic knowledge of the difference between plain and palatalized consonants in Russian?
2. Does such knowledge have a facilitative effect on the lexical encoding of contrasts involving palatalized consonants?

Our hypothesis concerning the first research question is that learners at lower levels of proficiency might have unstable orthographic and metalinguistic representations of the contrast between plain and palatalized consonants, whereas learners at the advanced level of proficiency should have more stable orthographic and metalinguistic representations. At lower levels of proficiency, learners can overlook metalinguistic explanations and fall into the spelling trap because Russian has a different script than English, the orthographic code is located on the neighboring letter, and the perceptual salience of palatalized consonants is not very high. At higher levels of proficiency, the concept of palatalization and the way it is represented in orthography becomes more salient not only for phonological reasons but also for morphological reasons. The stem system that governs Russian morphology involves almost all notional parts of speech. The endings in the synthetic Russian language, which uses bound morphemes to denote grammatical relationships, can differ depending on whether the stem ends in a palatalized or plain consonant. Thus, if learners want to speak and write grammatically in Russian, it is crucial that they know how to distinguish plain from palatalized consonants.

With respect to the second research question, it is hypothesized that orthographic and metalinguistic knowledge can be helpful in lexically representing plain and palatalized consonants in familiar words, especially if learners have some difficulty discriminating the contrast in perception. Even if encoding is imprecise, as long as learners create two separate categories for a lexical contrast with palatalized and plain consonants, it gives them an opportunity to refine their representations with experience and exposure. However, orthography can also do learners a disservice by fostering incorrect lexical encoding of palatalized consonants, especially in the prevocalic position. For example, if learners do not possess the necessary orthographic and metalinguistic knowledge of palatalization, they might believe that the difference between two words, such as <лук> *luk* "onion (bow)" and <люк> $l^{j}uk$ "manhole," pertains to the vowel and erroneously encode it as such. Thus, even though the words with plain and palatalized consonants might be encoded separately, the phonolexical representations will be inaccurate. Words that have palatalized consonants word-finally (i.e., marked with a soft sign letter <ь>) should not create this type of problem. On the contrary, the soft sign will signal that the consonant preceding it should be encoded differently than a plain consonant.

5 Method

Participants of the study performed eight tasks that evaluated their perceptual abilities, orthographic knowledge, phonolexical encoding, and production skills, which were part of a broader study (see Simonchyk, 2017). The task battery was administered to intact classes (i.e., not formed only for the purpose of the study) in the context of an intensive Russian summer program at a major Midwestern university. The students were tested during a regular Russian phonetics class that met for 50 minutes twice a week for eight weeks. For the purpose of the study and consistent with the Institutional Review Board human subjects procedures approved for the study, only the data of students who consented to be part of the study were used for further analysis. The data of students who did not consent were destroyed prior to analysis. The students were told that they would take a diagnostic test to evaluate their pronunciation. They were seated at individual workstations in a language laboratory and used Dell PCs and Logitech headsets H390 for the experiment. The entire testing session took 45 minutes. In this article, we only report on tasks that evaluated phonolexical encoding (an auditory word–picture matching task) and orthography (a written picture naming task with familiarization, and a metalinguistic task). Participants' familiarity with the experimental words was established separately. The following sections will describe the materials and procedures specific to each of these tasks.

5.1. Participants

Fifty-nine participants consented to have their data analyzed. The data from 19 participants were excluded from the analysis for the following reasons: three participants were heritage learners of Russian; five participants were native speakers of languages other than English (two Mandarin, two Spanish, one Lithuanian); five participants did not complete all tasks; four participants had a high error rate (more than two standard deviations) on the control words and/or distractors; and two participants were previously tested for the pilot study. The data obtained from the remaining 40 learners were used for further analysis. Proficiency was determined based on each participant's enrollment in one of nine levels of instruction offered in the intensive Russian summer program, which was the context of the study. Enrollment in levels was based on the results of an in-house placement test and previous experience with the language. The 40 participants were roughly distributed across levels 3–9 (with the exception of level 6, in which none of our participants was enrolled). The dataset was divided into two proficiency groups with 20 participants in each group (see Table 1). Learners enrolled in levels 3–5 were characterized as intermediate, whereas learners enrolled in levels 7–9 were considered advanced.

Three intermediate participants spent 1–2 months in a Russian-speaking country and another two participants stayed in Russia, Kazakhstan, or Kyrgyzstan for more than a year. Five intermediate participants had previous instruction in Russian pronunciation. Seventeen advanced participants had been to a Russian-speaking country (range 10 days to 2.5 years). Fourteen participants spent more than two months in Russia, Ukraine, Moldova, Armenia, Tajikistan, Kazakhstan, or Kyrgyzstan (M = 11.8, SD = 9.9). Six participants of the 14 spent more than a year in a Russian-speaking country. Seven participants reported having had previous instruction in Russian pronunciation.

Table 1. Overview of major demographic and learning characteristics of the two participant groups.

Group	Level	Chronological age at testing (years)	Age at which instruction began (years)	Length of Russian instruction
Intermediate	3 (n = 3)	M = 25.1	M = 19.5	<3 years
n = 20	4 (n = 5)	SD = 6.4	SD = 4.1	
11 females	5 (n = 12)	Range 19–40	Range 12-31	
Advanced	7 (n = 6)	M = 25.9	M = 20.1	>4 years
n = 20	8 (n = 8)	SD = 5.3	SD = 3.8	
8 females	9 (n = 6)	Range 22–41	Range 13–33	

Note. n, sample size; M, mean; SD, standard deviation.

Table 2. Real target words with underlined target consonants.

Position	Pair	Words with plain consonants			Words with palatalized consonants		
		Russian gloss	IPA	English gloss	Russian gloss	IPA	English gloss
Word-final:	t-tʲ	салат	*saˈlat̠*	salad	спать	*spat̠ʲ*	to sleep
VC / VCʲ	s-sʲ	адрес	*ˈadrʲes̠*	address	здесь	*zdʲes̠ʲ*	here
	n-nʲ	экзамен	*ekˈzamʲen̠*	exam	осень	*ˈosʲen̠ʲ*	fall
	l-lʲ	стол	*stol̠*	table	соль	*sol̠ʲ*	salt
	r-rʲ	сахар	*ˈsaxar̠*	sugar	словарь	*sloˈvar̠ʲ*	dictionary
Inter-vocalic:	t-tʲ	газета	*gaˈzʲet̠a*	newspaper	тётя	*ˈtʲot̠ʲa*	aunt
VCV / VCʲV	s-sʲ	писать	*pʲiˈs̠atʲ*	to write	тысяча	*ˈtis̠ʲatʃa*	thousand
	n-nʲ	жена	*ʒeˈn̠a*	wife	таня	*ˈtan̠ʲa*	Tanya
	l-lʲ	холодный	*xoˈl̠odnij*	cold	зелёный	*zʲeˈl̠ʲonij*	(name)
	r-rʲ	серый	*ˈsʲer̠ij*	grey	курица	*ˈkur̠ʲitsa*	green
							chicken

Ten Russian native speakers (two males, eight females) aged 26–42 years ($M = 33.3$, $SD = 5.8$) served as a control group and performed the same tasks as the American learners of Russian. In total, the data from 50 participants (40 learners and 10 native speakers) were analyzed.

5.2. Materials

The materials for all the tasks reported here are based on five pairs of plain coronal consonants and their palatalized counterparts that differed only in the secondary feature of articulation: /t/–/tʲ/, /s/–/sʲ/, /n/–/nʲ/, /l/–/lʲ/, /r/–/rʲ/. These specific pairs were chosen on the basis of extensive piloting and availability of suitable familiar words. Voiced coronal obstruents /d/–/dʲ/, /z/–/zʲ/ were excluded because word-finally they are devoiced in Russian, which could be a confounding variable. Labials were not included because potential target words that ended in /pʲ/, /bʲ/, and /fʲ/ were unlikely to be familiar to intermediate students. Dorsals were avoided because palatalized dorsals do not occur word-finally in Russian.

Target consonants were embedded in word-final and intervocalic positions. Word-initial position was not used because words starting with initial coronals and matching the inclusion criteria were unfamiliar to learners at the lower level of proficiency.

The selection process of real target words was guided by several criteria. First, only words that were familiar to students at all levels of proficiency were included (Table 2). The words were chosen from the Russian–English vocabulary provided in the textbook *Live from Russia. Volume 2* (Lekić, Davidson, & Gor, 1997) that is widely used in first-year Russian courses. Second, an effort was made to control for the phonetic environment surrounding target consonants. In word-final position, all target consonants were preceded by the same vowel. The palatalized realization of the consonant preceding the vowel was also controlled for. In intervocalic position, all target consonants occurred between two vowels. The vowels that followed the target consonants were the same in words that formed pairs. For instance, in *gaˈzʲeta* and *ˈtʲotʲa*, the voiceless stops /t/ and /tʲ/ in the ultimate syllables were followed by /a/. For these pairs, the preceding vowel varied (see Table 2). It was deemed more important to control for the following vowel due to the possibility that learners pay more attention to the following vowel when perceiving the plain/palatalized distinction. Similarly, it was not possible to control for the number of syllables, stress, and part of speech due to the limits imposed by the vocabulary size of low to intermediate participants.

For each target word, a triplet consisting of the target word and two nonwords was created (see Appendix). The two types of nonwords were test nonwords and control nonwords. For the test nonwords, the change involved exchanging a plain consonant by its palatalized counterpart and vice versa (e.g., a target word *solʲ* "salt" was made into a test nonword by exchanging the final consonant by a plain one, **sol*). For the control nonwords, the change always involved other primary contrasts (e.g., **somʲ*). Ten filler words (distractors) that were semantically connected to the target words were added to divert learners' attention from the phenomenon under investigation: *dom* "house," *tam* "there," *zʲiˈma* "winter," *tʃiˈtatʲ* "read," *ˈdʲesʲatʲ* "ten," *ˈmʲiʃa* "Misha (male name)," *sok* "juice," *tort* "cake," *ˈsumka* "purse," *ˈkrasnij* "red." All stimuli were recorded by a female Russian native speaker and saved as individual audio files.

5.3. Procedure

The first task that the participants performed was the familiarization task. The goal of the task was to ensure that the participants would produce the selected target words. Each target word was associated with a picture to denote the meaning of that word (Figure 1). The participants saw a picture presented via a timed PowerPoint presentation and heard the pronunciation of that word. The participants did not see the written forms of the target words except for the first two letters. Each picture was presented two times for three seconds in a random order.

Then the participants performed a written picture naming task. They saw the same pictures they knew from the familiarization task and were asked to write words that matched the pictures on the provided answer sheets. The task was self-paced. The participants did not hear the pronunciation of the target words while completing this task. The first two letters were provided to facilitate retrieval. Thus, in total, 1500 words ((20 target words + 10 distractors) × 50 participants) were written, but only the 1000 target words were analyzed.

The auditory word–picture matching (AWPM) task was administered after the written picture naming task. The goal of the AWPM task was to determine whether learners had separately encoded plain and palatalized consonants in their lexical representations for these words, or whether the contrast was lexically neutralized. During the task, participants saw a picture and had to decide whether the pronunciation of the item they heard was correct and matched the picture by pressing a designated button "Yes" or "No." The participants were warned that some of the items were nonwords, and they did not see the written forms of the words. In total, the task included 80 trials split into four conditions: 20 target words (e.g., *solʲ* "salt"); 20 test nonwords (e.g., **sol*); 20 control nonwords (e.g., **somʲ*); and 20 filler trials (10 distractors × 2 presentations, e.g., *ˈsumka* "purse"). For example, the participants saw a picture of salt and heard either the word "salt" *solʲ*, with a palatalized consonant word-finally or a nonword **sol* with a plain final consonant. The target words

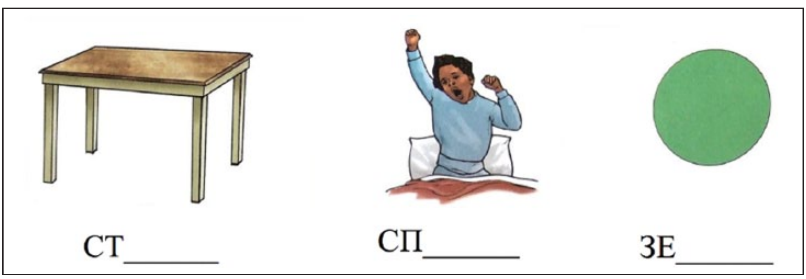

Figure 1. Sample pictures of target words: <стол> *stol* "table," <спать> *spatʲ* "to sleep," <зелёный> *zʲeˈlʲonij* "green."

Table 3. An example of a block for plain /l/ and palatalized /l^j/ in word-final position.

Picture	Stimulus (* = nonword)	Response	Condition
Table	stol	Yes	Target word
Table	*stol^j	No	Test nonword
Table	*stor	No	Control nonword
Purse	ˈsumka	Yes	Distractor
Salt	sol^j	Yes	Target word
Salt	*sol	No	Test nonword
Salt	*som^j	No	Control nonword
Purse	ˈsumka	Yes	Distractor

Table 4. Coding used in the written picture naming and metalinguistic tasks.

Target	Supplied forms	Written picture naming task	Metalinguistic task
Palatalized example	соль	1	1
<соль> *sol^j* "salt"	соль	1	0
	сол	0	0
	сол	0	1
Plain example	стол	1	1
<стол> *stol* "table"	стол	1	0
	столь	0	1
	столь	0	0

Note: Letters that were circled by the participants are underlined in the table.

and distractors were paired with their corresponding pictures and required a "yes" answer because they were all real words. The test nonwords and control nonwords were paired with the picture of the target word and required a "no" answer due to the segmental mismatch (see Table 3). Ten distractors were presented twice, for a total of 20 trials. Together with the 20 real target words, there were 40 trials in the experiment requiring a "yes" answer. An equal number of 40 trials required a "no" answer (test and control nonwords). The distractors were repeated to equalize somewhat the fact that the picture for the target words was also presented more than once, since it was paired with the nonwords in the triplet.

Stimuli were presented with DMDX (Forster & Forster, 2003). Picture and audio files were presented simultaneously in each trial. The picture disappeared after 2000 ms or as soon as the participant gave an answer. All trials were randomized. The auditory word-picture matching task produced 4000 data points (80 trials × 50 participants). Errors were tallied and reaction times (RTs) were measured.

In the metalinguistic task, participants were returned their answer sheets from the written picture naming task, and were asked to circle all palatalized (or soft) consonants in the words that they had supplied. If participants explicitly asked whether they should circle vowels, the instructions were repeated, i.e., "circle soft or palatalized consonants." The answers from both tasks were coded so that each correct answer on either task received one point (Table 4). It is important to mention that even if participants spelled the word incorrectly in the written picture naming task—for example, *<сол> instead of <соль>—they could still receive a point in the metalinguistic task if they circled the final consonant as palatalized.

As a result, out of 500 palatalized target consonants present in the sample (100%), the participants failed to identify 61 palatalized consonants in word-final position (12%) and 104 palatalized consonants in intervocalic position (21%). The participants circled 189 palatalized consonants in word-final position (38%). In intervocalic position, participants used different ways to identify palatalization. They circled 121 palatalized consonants (24%), 14 palatalized consonants together with the following vowels (3%), and 11 vowels following palatalized consonants without including the consonants themselves (2%). These results show that participants were mostly familiar with the term "soft or palatalized consonants" and rarely confused it with the vowels following palatalized consonants. For further analysis, the instances in which learners circled vowels following palatalized consonants or when they circled palatalized consonants together with the subsequent vowels were counted as accurate identifications of palatalization. Even though the participants were mistaken or uncertain about the exact source of palatalization, they were aware of its presence in that syllable position of the target words. Moreover, the fact that learners identified vowels instead of palatalized consonants only in 8% of all identified palatalized consonants in intervocalic position suggests that these were occasional incidences rather than a general trend.

Participants' familiarity with the target words was evaluated at the very end of the testing session. They received a list of the target words and distractors in Russian that were used in the experiment. Learners were asked to translate the words into English and choose one of the three following categories that best described their knowledge of each word: (1) I have seen it, I know it, I can use it; (2) I saw it, I don't know it; (3) I never saw it, I don't know it. Russian native speakers were asked to translate the words into English and mark how familiar the words were to them using a seven-point scale: 7 = very familiar, 1 = unfamiliar. Only nine target words (1.1%) out of 800 responses (20 target words × 40 learners) were not very familiar to the American English learners. Russian native speakers were able to translate all the words accurately and marked them as very familiar—that is, they chose 7 on the seven-point scale. All distractors used in the study were marked as familiar and translated accurately by learners and Russian native speakers.

6 Results

6.1. Auditory word–picture matching task

Overall, the error rates in all conditions were low for all groups, except in the test nonword condition, where the two learner groups displayed a high error rate (Figure 2). A generalized linear mixed model was run in SPSS 24 on the error rates first. The factors group (Russian native speakers, advanced learners, intermediate learners) and condition (word, test nonword, control nonword, distractor) were declared as fixed effects. The factors participant and item were chosen as random effects. Type III tests of fixed effects for error rates revealed that there was a main effect of group, $F(2, 3988) = 30.53$, $p < 0.001$, condition, $F(3, 3988) = 93.6$, $p < 0.001$, and an interaction between the two factors, $F(6, 3988) = 14.25$, $p < 0.001$. Bonferroni post-hoc tests showed that intermediate learners with a mean error rate of 82% (95% CI = 77–85) made significantly ($p = 0.008$) more errors than advanced learners with a mean error rate of 74% (CI = 69–78) in the nonword condition, when presented with test nonwords **sol* or **stol^j* instead of the real words *sol^j* "salt" or *stol* "table." The confidence intervals for the two groups' means on this condition were not overlapping but very close, and the mean difference between the two average error rates was 8 (CI = 2–14), suggesting that the difference between the two groups was not extremely large. Both groups of learners were significantly less accurate than Russian native speakers ($M = 4\%$, CI = 2–8) ($p < 0.001$ for both groups of learners) on this condition. The mean difference between advanced learners' and Russian native speakers' average error rates was 69 (CI = 63–76) and the mean difference

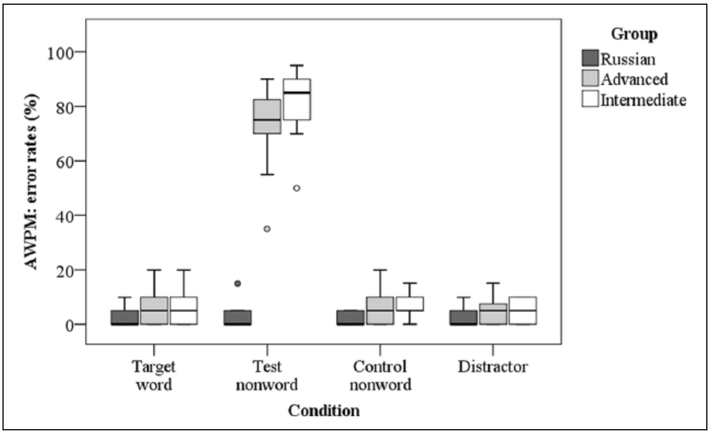

Figure 2. Box plots of error rates for each group of participants and condition on the auditory word-picture matching task (AWPM). Horizontal lines are medians, boxes show the interquartile range (IQR) representing 50% of the cases, whisker bars extend to 1.5 times the IQR. Outliers (circles) are cases with values between 1.5 and 3 times the IQ range (i.e., beyond the whiskers).

between intermediate learners' and Russian native speakers' error rates was 77 (CI = 72–83), indicating a robust effect.

As shown in Figure 3, learners indeed processed test nonwords differently from any other condition. RTs were measured from the beginning of the audio file. Since target consonants could occur in different syllables within a word, it was decided to adjust the RTs for analysis by subtracting the duration of the audio file. Only RTs for correct answers were included in the analysis. A linear mixed effects model was run on RTs declaring group (Russian native speakers, advanced learners, intermediate learners) and condition (word, test nonword, control nonword, distractor) as fixed effects and participant and item as a random effect. Type III tests of fixed effects for RTs revealed a main effect of group, $F(2, 49.12) = 16.05$, $p < 0.001$, condition, $F(3, 78.95) = 19.85$, $p < 0.001$, and a significant interaction between group and condition, $F(6, 3122.33) = 20.09$, $p < 0.001$. Bonferroni post-hoc tests showed that both groups of learners spent significantly more time ($p < 0.001$ for both groups and all conditions) on test nonwords (intermediate: $M = 771$ ms, CI = 718–823; advanced: $M = 790$ ms, CI = 746–834 ms) than on real words (intermediate: $M = 516$ ms, CI = 493–540; advanced: $M = 573$ ms, CI = 549–596), control nonwords (intermediate: $M = 528$ ms, CI = 505–552; advanced: $M = 588$ ms, CI = 565–611), or distractors (intermediate: $M = 470$ ms, CI = 447–493; advanced: $M = 569$ ms, CI = 546–593). The learners' processing of test nonwords was on average 240 ms slower, which appears to be a strong effect as shown by the wide gap between the confidence intervals for the test nonwords and all other conditions. Despite the fact that learners spent significantly more time on test nonwords, their error rates in accepting these nonwords were extremely high. Russian native speakers did not process test nonwords ($M = 441$ ms, CI = 409–474) differently than real words ($M = 433$ ms, CI = 401–465), control nonwords ($M = 447$ ms, CI = 415–479), or distractors ($M = 400$ ms, CI = 368–432).

An additional generalized linear mixed model was run on the error rates in the nonword condition only to examine the effects of syllable position and the palatalization status of the target consonants. The factors group (Russian native speakers, advanced learners, intermediate learners), position (final, intervocalic), and palatalization status (plain, palatalized) were declared as fixed effects. The factor participant was chosen as a random effect. Type III tests of fixed effects for error

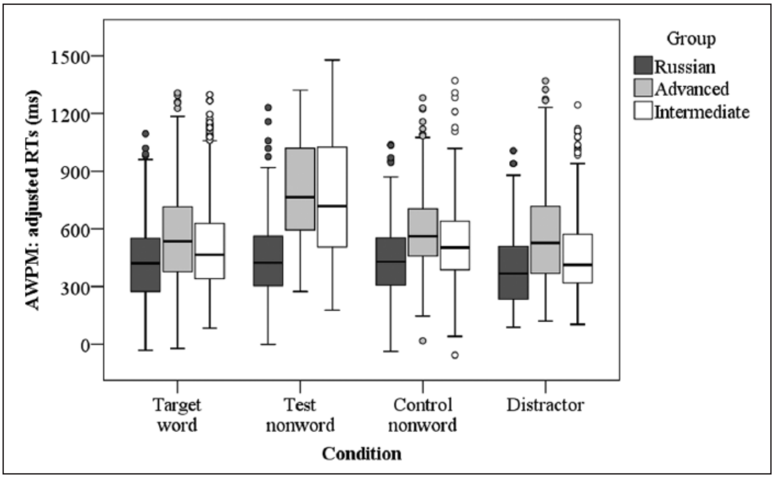

Figure 3. Box plots of RTs for each group of participants and condition on the auditory word-picture matching task (AWPM). See the caption for Figure 2 for an explanation of the box plot.

rates revealed that there was a main effect of group, $F(2, 995) = 56.59$, $p < 0.001$, palatalization, $F(1, 995) = 4.4$, $p = 0.036$, and position, $F(1, 995) = 53.68$, $p < 0.001$, but no significant interactions.

Additional generalized linear mixed models were run on the error rates to examine the effects of syllable position and palatalization for each group separately. No main effects of syllable position or palatalization were found in the data of Russian native speakers. There was a main effect of position, $F(1, 396) = 20.05$, $p < 0.001$, in the data of intermediate learners, who made significantly ($p < 0.001$) more errors in the word-final position ($M = 91\%$, CI = 84–96) than in the intervocalic position ($M = 73\%$, CI = 62–82). Confidence intervals did not overlap, and the mean difference was 18 (CI = 7–29). There was also a main effect of position, $F(1, 396) = 32.12$, $p < 0.001$, as well as a marginally significant effect of palatalization, $F(1, 396) = 3.77$, $p = 0.053$, and a marginally significant interaction between position and palatalization, $F(1, 396) = 3.77$, $p = 0.053$, in the data of advanced learners. Overall, advanced learners also made more errors in word-final ($M = 87\%$, CI = 81–92) than in intervocalic ($M = 61\%$, CI = 52–69) position. In intervocalic position, the error pattern was modulated by palatalization. Advanced learners made significantly ($p < 0.001$) more errors by accepting test nonwords with a plain consonant ($M = 72\%$, CI = 61–81)—for example, **zʲeˈlonij* instead of *zʲeˈlʲonij* “green,”—than test nonwords with a palatalized consonant ($M = 49\%$, CI = 38–60)—for example, **xoˈlʲodnij* instead of *xoˈlodnij* “cold” (Figure 4). Again, the confidence intervals of the two distributions were not overlapping, and their mean difference was 24, CI = 10–37, suggesting a rather strong asymmetry effect.

6.2. Written picture naming and metalinguistic tasks

In the written picture naming task, the participants supplied written forms of the words that they saw in the pictures. Only errors in the plain or palatalized status of the target consonants were considered. Russian native speakers wrote all consonants (plain and palatalized) accurately. Both advanced and intermediate learners had an error rate of 4%, which suggests that learners were very familiar with the orthographic representations of the plain and palatalized consonants in the target

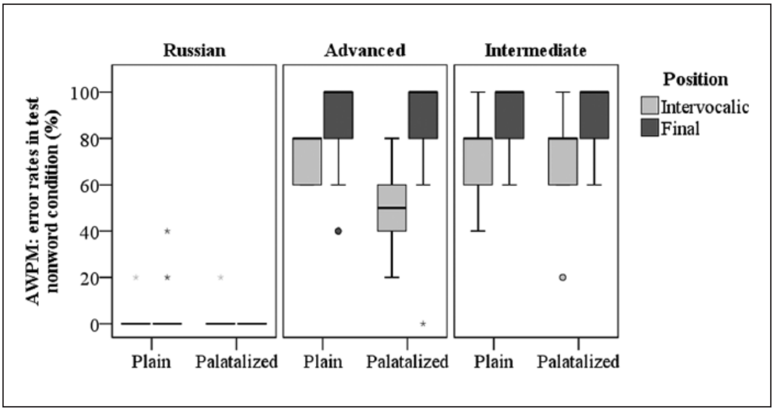

Figure 4. Box plots of error rates on test nonwords with plain and palatalized consonants in intervocalic and word-final positions for each group of participants on the auditory word-picture matching task (AWPM). See the caption for Figure 2 for an explanation of the box plot.

words. A generalized linear mixed model was run in SPSS 24 on the error rates from the written picture naming task to examine the effects of group, syllable position, and the palatalization status of the target consonants. The factors group (Russian native speakers, advanced learners, intermediate learners), position (final, intervocalic), and palatalization status (plain, palatalized) were declared as fixed effects. The factor participant was chosen as a random effect. Type III tests of fixed effects for error rates revealed no significant main effects or interactions. All participants were able to supply accurate plain and palatalized orthographic representations for the target consonants in the target words.

In the metalinguistic task, participants were asked to circle all palatalized consonants in the words that they had supplied in the previous written task. Russian native speakers had a mean error rate of 2% (*SD* = 14%), advanced learners' error rate was 24% (*SD* = 43%), and intermediate learners made 25% (*SD* = 43%) errors. Advanced learners incorrectly identified 38% (*SD* = 49%) of palatalized consonants and 11% (*SD* = 32%) of plain consonants, whereas intermediate learners had an error rate of 42% (*SD* = 50%) in the identification of palatalized consonants and 7% (*SD* = 26%) in the identification of plain consonants. In order to determine whether syllable position or the palatalization status of the target consonant had an effect on learners' ability to identify plain and palatalized consonants, a generalized linear mixed model was run in SPSS 24 on the error rates in the metalinguistic task. The factors group (Russian native speakers, advanced learners, intermediate learners), position (final, intervocalic), and palatalization status (plain, palatalized) were declared as fixed effects. The factor participant was chosen as a random effect. Type III tests of fixed effects for error rates revealed that there was a significant interaction between group, position, and palatalization status, $F(7, 983) = 3.12$, $p = 0.003$. In the intervocalic position, both groups of learners made significantly more errors ($p < 0.001$ for both groups) when identifying palatalized consonants (intermediate: $M = 53\%$, CI = 45–60; advanced: $M = 47\%$, CI = 40–54) than plain consonants (intermediate: $M = 8\%$, CI = 1–15; advanced: $M = 5\%$, CI = −2–12), which means that learners did not circle half of the palatalized consonants followed by palatalized series vowels <е>, <ё>, <и>, <ю>, <я> (Figure 5). In the word-final position, learners also made more errors ($p < 0.001$ for intermediate, $p = 0.058$ for advanced) when identifying palatalized consonants (intermediate: $M = 32\%$, CI = 25–39; advanced: $M = 28\%$, CI = 21–35) than plain consonants (intermediate: $M = 6\%$, CI = −1–13;

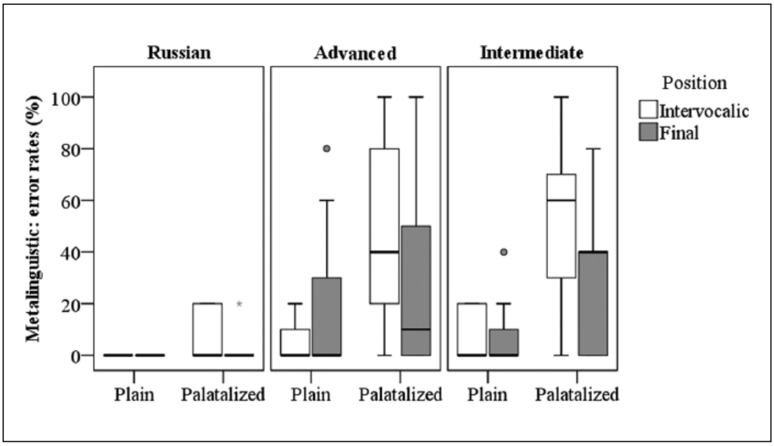

Figure 5. Box plots of error rates on plain and palatalized consonants in intervocalic and word-final positions for each group of participants on the metalinguistic task. See the caption of Figure 2 for an explanation of the box plot.

advanced: $M = 17\%$, CI = 10–24), which means that learners did not circle one-third of the palatalized consonants followed by the soft sign <ь>. Both groups of learners were more likely ($p < 0.003$ for intermediate, $p < 0.002$ for advanced) to identify palatalized consonants that were followed by the soft sign <ь> than when followed by palatalized series vowels <е>, <ё>, <и>, <ю>, <я>. There was no statistically significant difference between intermediate and advanced learners in their error rates on identification of plain and palatalized consonants in either syllable position. Russian native speakers' performance was affected neither by the palatalization status of the target consonants nor their syllable position.

Data obtained from the participants on the written picture naming task were combined with the data from the metalinguistic task to determine whether learners were aware of the phonological categories that the graphemes they had supplied represented. Four conditions were created depending on whether learners were able to write the target words accurately with respect to the palatalization status of the target consonants (± spelling) and whether they were able to accurately identify plain and palatalized consonants (± metalinguistic). Figure 6 represents the percentage of target consonants in each condition. Russian native speakers were able to correctly identify plain and palatalized consonants in 98% of correctly spelled target words, whereas learners were only able to successfully identify the same consonants in 75% of words. In 21% of the correctly spelled words, learners were unable to identify the plain or palatalization status of the target consonants. This finding suggests that learners' ability to write a word accurately does not imply that learners were metalinguistically aware of what phonemes were represented by the graphemes they had actually used.

6.3. Correlations

Learners' performance on the AWPM task was correlated with their performance on the written picture naming and metalinguistic tasks to examine the relationship between orthography and lexical encoding (Figure 7). A separate correlational analysis for each group was performed on the error rates in the written picture naming and metalinguistic tasks and the error rates in the test nonword condition of the AWPM task. No significant relationship was found between learners'

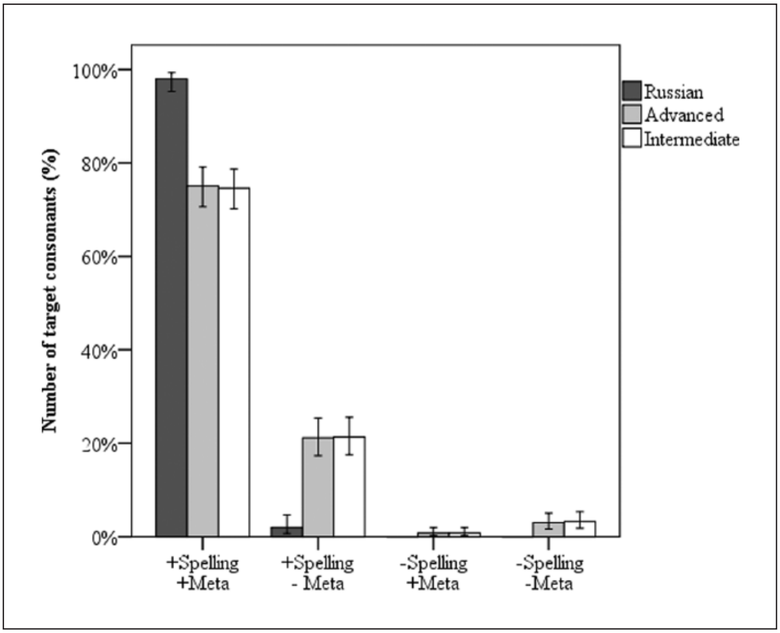

Figure 6. Percentage of target consonants for each group of participants and condition on the metalinguistic task (meta) and written picture naming task (spelling); error bars show the 95% confidence interval.

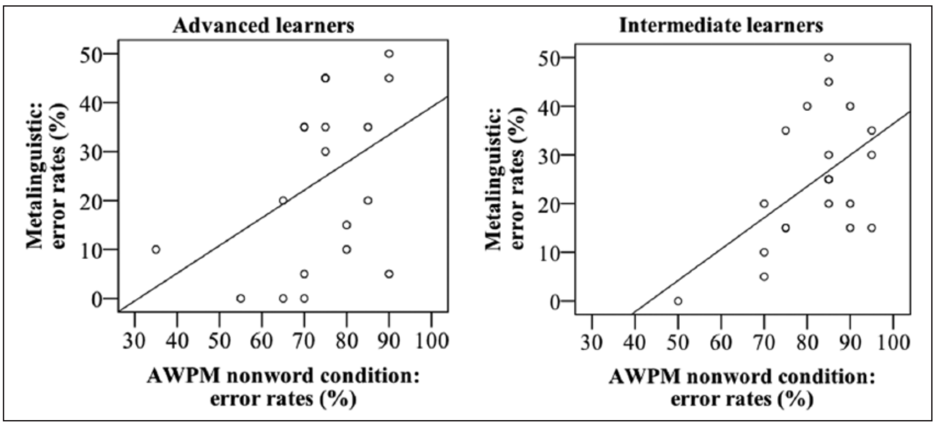

Figure 7. Scatterplots of error rates on the metalinguistic task and auditory word-picture matching task (AWPM). Left panel: advanced learners; right panel: intermediate learners.

performance on the written picture naming task and the AWPM task, which means that their ability to accurately write words with the target contrasts was not related to their ability to establish separate categories for words with plain and palatalized consonants in the mental lexicon. However, there was a moderate, positive, statistically significant relationship between error rates in the

AWPM and metalinguistic tasks for the advanced group, $r(18) = 0.416$, $p = 0.034$, and a strong, positive, statistically significant relationship between error rates in the AWPM and metalinguistic tasks for the intermediate group, $r(18) = 0.532$, $p = 0.008$. Consequently, higher error rates in the metalinguistic task were related to higher error rates in the AWPM task.

7 Discussion

The current study sought to investigate the relationship between orthography and the lexical encoding of plain and palatalized consonants in L2 Russian. The first research question asked whether American learners of Russian possessed orthographic and metalinguistic knowledge of the plain/palatalized contrast in Russian. We hypothesized that learners at lower levels of proficiency might have unstable orthographic and metalinguistic representations of palatalized consonants, whereas learners at the higher levels of proficiency should have more accurate orthographic and metalinguistic knowledge due to their increased experience with the Russian language. These hypotheses were partially confirmed by the results. Intermediate and advanced learners behaved very similarly on the written picture naming task and metalinguistic task despite their differences in proficiency and experience with the language (intermediate learners studied Russian for a maximum of three years, advanced learners studied Russian for a minimum of four years). Both groups of learners demonstrated highly accurate orthographic knowledge of palatalized consonants but less stable metalinguistic knowledge. In the written picture naming task, intermediate and advanced learners behaved similarly to the Russian native speakers and were able to write 96% of all words accurately with respect to the plain or palatalized status of the target consonants. However, when asked in the metalinguistic task to circle palatalized consonants in the supplied words, learners made errors in more than 20% of target consonants. Taken together, the results of the written picture naming task and metalinguistic task reveal that there is a clear distinction between the knowledge of the written forms of words (namely, orthographic knowledge) and the knowledge of what phonemes the graphemes in these words represent (namely, metalinguistic knowledge).

Interestingly, learners demonstrated an asymmetrical error pattern with respect to the syllable position and palatalization status of the target consonants on the metalinguistic task. They made significantly more errors when identifying palatalized rather than plain consonants, which suggests that learners did not utilize the orthographic code for palatalization: the soft sign <ь> word-finally and palatalized series vowel letters <е>, <ё>, <и>, <ю>, <я> in the intervocalic position. Learners made more errors in intervocalic position than in the word-final position. That is, identifying palatalized consonants was more difficult when they were followed by vowels than when they were followed by the soft sign. This pattern can possibly be explained by a difference in orthographic salience between the two positions. Even though palatalized and plain consonants share the same graphemes in Russian, palatalization is not opaque, as was explained earlier. The Russian vowel system consists of only five vowel sounds—/i/, /e/, /a/, /o/, /u/—but it uses ten vowel letters which specifically mark plain and palatalized consonants in the prevocalic position. With respect to the intervocalic position, learners might have fallen into a spelling trap and thought that consonants followed by palatalized and plain series vowels were the same, and that the vowels were different, whereas in reality the consonants differ in their palatalization status but the vowels are the same. In the word-final position, palatalization is orthographically more salient, and learners' performance was significantly more accurate. In Russian, word-final palatalized consonants are followed by the letter called the soft sign <ь>. The name of the letter "soft sign" might have alerted learners that consonants preceding it should be palatalized because in Russian linguistics, palatalized consonants are called "soft."

The second research question investigated the relationship between orthography and lexical encoding in order to determine whether orthographic and metalinguistic knowledge facilitate the lexical encoding of words with plain and palatalized consonants. We hypothesized that either type of knowledge could facilitate the lexical encoding of this contrast, especially if learners had difficulty discriminating the contrast in perception. For example, in the perceptually nonsalient word-final position, the soft sign <ь>, which is used to mark palatalized consonants, would signal that the consonant preceding it should be encoded differently than a plain consonant. However, in the prevocalic position, orthography was hypothesized to have an inhibiting effect on the accurate lexical encoding of palatalized consonants due to the difference in vowel graphemes following plain and palatalized consonants or the so-called spelling trap.

The results of the AWPM task showed that learners did not encode the contrast between plain and palatalized consonants with high precision even in familiar words, despite their excellent orthographic knowledge and relatively stable metalinguistic knowledge. Unlike Russian native speakers, learners mistakenly accepted most test nonwords (but not control nonwords) as correct productions of Russian words. Learners' performance on the AWPM task was correlated with their performance on the metalinguistic task. Learners with higher error rates on the metalinguistic task had higher error rates on the AWPM task. Surprisingly, there were four learners who identified 100% of the plain and palatalized consonants accurately on the metalinguistic task, but their error rates on the AWPM task ranged from 50% to 70%. It seems that metalinguistic knowledge of how palatalization is represented in orthography was not very facilitative in establishing separate categories for plain and palatalized consonants in lexical representations since the error rates were so high. However, these four learners with 0% error rates on the metalinguistic task also had the lowest error rates on the AWPM. Thus, despite overall high error rates on the AWPM task, learners who demonstrated excellent metalinguistic knowledge also had the best performance on the AWPM task, even though this "best" performance was a 50–70% error rate. Of note, performance on control nonwords which only differed from real words in one segment was excellent and not different from native speakers. This suggests that learners did not accept all nonwords indistinctly, and that their lexical representations for familiar words were in fact sufficiently detailed at the level of common segmental contrasts. Rather, the difficulty appears centered on the plain/palatalized contrast, which seems to not be robustly encoded in the long-term lexical representations for these familiar words.

The syllable position of the target consonants affected the performance of both groups of learners on the AWPM task. Learners erroneously accepted nonwords with target consonants more often in word-final position than in intervocalic position. Previous studies suggest that the plain/palatalized contrast in prevocalic position is perceptually more salient than in word-final position, given that the i-transition accompanying palatalized consonants prevocalically serves as a vowel cue (Kochetov, 2002, 2004; Lukyanchenko & Gor, 2011; Rice, 2015). In a follow-up study, Simonchyk and Darcy (2017) tested the same participants using an ABX task on the perception of plain and palatalized consonants. The results showed that indeed both intermediate and advanced learners made significantly more errors in the word-final position (intermediate: M = 37%; advanced: M = 43%) than the intervocalic position (intermediate: M = 18%; advanced: M = 17%). There was no statistically significant difference between the two groups of learners. Thus, in the AWPM task, the additional acoustic cues carried by vowels might have made the difference between words and nonwords with plain and palatalized consonants more salient to learners, as shown by their lower error rates in the intervocalic position. However, on the metalinguistic task, learners made significantly more mistakes identifying palatalized consonants in the intervocalic position than the word-final position. Thus, although learners were able to perceive the difference between words and nonwords in intervocalic position, the results of the metalinguistic task showed that learners did not circle the palatalized consonants in these words. It indicates that learners likely assigned the source of this perceptual difference to the following vowels that carry the orthographic code rather than the target consonants. Taken together, these findings confirm our hypothesis that learners fall into the spelling trap and make a mistake when they lexically encode the difference between plain and palatalized consonants in intervocalic position in terms of subsequent vowels, rather than the consonants themselves. For example, the difference between the words /luk/ “onion” and /l^{j}uk/ “manhole” can be erroneously encoded as /luk/ versus /lyk/, or /luk/ versus /l*k/, where /*/ might mean any sound different from /u/ (Darcy, Daidone, & Kojima, 2013; Hayes-Harb & Masuda, 2008).

In word-final position, learners’ performance on the metalinguistic and AWPM tasks was reversed. Learners made fewer errors identifying palatalized consonants on the metalinguistic task and more errors accepting nonwords on the AWPM task, which did not support our hypothesis that orthography would have a facilitative effect on the lexical encoding of palatalized consonants, particularly in word-final position. Perceptually, the difference between plain and palatalized consonants word-finally is quite subtle. When Lukyanchenko and Gor (2011) examined the perception of palatalized and plain consonants using a high-variability AX task, they found that in word-final position, learners of Russian, despite years of instruction and practice with the language, were not significantly different from naïve English speakers without any knowledge of Russian. American learners of Russian tend to map plain and palatalized consonants to similar English categories—for instance, Russian /p/ and /p^j/ could be mapped to the English /p/ (Rice, 2015).

It may be that learners’ inability to discriminate plain and palatalized consonants word-finally in perception interfered with their lexical encoding of the contrast despite the fact that learners were aware of the plain or palatalized status of the consonants in the target words. Showalter and Hayes-Harb (2015) describe a similar situation whereby a lack of perceptual ability overrode the benefit of metalinguistic and orthographic knowledge in encoding a perceptually challenging contrast. Their study investigated how native speakers of American English encoded novel nonwords written in Arabic script with the /k/–/q/ contrast. Participants were assigned either to a group in which Arabic script was available for learning nonwords or to a group lacking orthographic support. After the word-learning stage, participants performed an AWPM task. The results revealed no difference between the two groups. Subsequent manipulation of the quality of the orthographic input, including additional instruction in Arabic script, did not lead to any changes between the two groups. Even when the target words were presented to the participants using the Roman alphabet, their performance decreased. The authors speculated that the velar–uvular contrast was very difficult for the participants to perceive. Moreover, the use of the Roman letters <k> and <q>, which represent the same phoneme /k/ in English, might have fully neutralized the contrast in perception and led to the development of inaccurate lexical representations.

The AWPM task revealed an effect for palatalization status only in the performance of advanced learners. Intermediate learners accepted nonwords with either plain or palatalized consonants regardless of syllable position, whereas advanced learners showed an asymmetry in intervocalic position, rejecting test nonwords with a palatalized consonant much more often than nonwords with a plain consonant. Such asymmetry in error rates is reminiscent of findings that rejecting a nondominant (palatalized) category as incorrect in test nonwords is somewhat “easier” than rejecting a dominant (plain) category (Cutler et al., 2006; Darcy et al., 2013; Weber & Cutler, 2004). The L2 category that is most similar to the native category is considered to be dominant—that is, plain consonants in Russian are phonetically similar to their English consonant equivalents. Palatalized consonants represent new categories for American English learners of Russian. Due to their potential perceptual confusion with the plain counterparts, they represent nondominant categories. In a classic study by Weber and Cutler (2004), Dutch listeners did not activate the word “panda” when they heard the word "pencil," which contains the dominant Dutch-like category /ɛ/. On the other hand, when they heard the word "panda" with a confusable nondominant category /æ/, the participants activated both words. A similar effect was observed in another study with Japanese learners, who could not discriminate between the English sounds /ɹ/ and /l/ and activated the word "locker," when they heard the word "rocket," but not vice versa (Cutler et al., 2006). In the current study, learners were more willing to reject the nonword **xoˈlʲodnij* with a nondominant palatalized category /lʲ/ (the real word being *xoˈlodnij*) than the nonword **zʲeˈlonij* with a dominant plain category /l/ (the real word being *zʲeˈlʲonij*). Further research with a different experimental paradigm, such as the use of an eye-tracking or a lexical decision task, is needed to uncover the processing characteristics of plain and palatalized consonants by learners of Russian.

Concluding, the ability to spell words with plain and palatalized consonants correctly does not imply that learners possess accurate and complete orthographic knowledge of palatalization. In order to correctly identify palatalized consonants in orthography, learners have to possess metalinguistic knowledge of the orthographic codes that are used in Russian to mark palatalization. In the intervocalic position, the orthographic code for palatalization is realized through the use of special vowels that follow plain and palatalized consonants. These vowels also carry additional vocalic cues, which help learners perceive the difference between plain and palatalized consonants. Our findings revealed that learners erroneously rely on the vowels following plain and palatalized consonants rather than the consonants themselves to encode plain/palatalized contrasts in Russian. In the word-final position, the difference between plain and palatalized consonants is marked by the absence or presence of the soft sign <ь> grapheme following the consonant. Even though learners seem to be aware of the function of this letter and can accurately identify the plain or palatalized status of final consonants orthographically, they still fail to encode the contrast due to a lack of perceptual ability to discern plain and palatalized consonants in this syllable position. Thus, the effect of orthography on the lexical encoding of palatalized consonants in L2 Russian reveals itself differently depending on the syllable position of the target consonants and the corresponding difference in graphemes employed to mark palatalization in orthography.

Generally, we did not find a clear link between learners' orthographic and metalinguistic knowledge on the one hand and accurate lexical encoding on the other hand. Very high error rates on the AWPM task (78%), extremely low error rates on the written picture naming task (4%), and relatively low error rates on the metalinguistic task (25%) suggest that if there is such a link, the effects of knowing the orthography are not spontaneous and immediate, at least in the case of the Russian plain/palatalized contrast. The updating of lexical representations may take a substantial amount of time. What we observed in our learners' performance on highly familiar words is that they have clearly not yet reached an accurate phonolexical encoding of words with plain and palatalized consonants, regardless of how well they knew the orthography. This might be a consequence of ignoring orthographic information combined with experiencing perceptual difficulties discerning the plain/palatalized contrasts in the early stages of acquisition. As a result, even though learners are now able to perceive the difference between plain and palatalized consonants to some degree and possess the necessary orthographic and metalinguistic knowledge, they still have not updated their lexical representations of words using palatalized consonants. Further research might uncover whether learners at later stages of acquisition can correctly encode novel words with the plain/palatalized contrasts and whether this process is easier than updating the "entrenched" forms of familiar words.

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Notes

1. All Russian words in this article are provided through transliteration using the IPA symbols, set in italics and without slanted brackets, to avoid the controversy concerning the use of phonemes versus morphophonemes in the Russian language (see Halle, 1959, for discussion). The controversy, however, does not concern plain and palatalized consonants and does not affect the analysis conducted in this investigation.
2. However, the vowels following palatalized consonants are phonetically more fronted and raised than those that follow plain consonants (Avanesov, 1972).

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Appendix. Target words with underlined target consonants, test nonwords, and control nonwords.

Positions	Pairs	Target words	Test nonwords	Control nonwords	Gloss
Word-final:	t–tʲ	*saˈlat*	*saˈlatʲ*	*saˈlar*	salad
VC/VCʲ	s–sʲ	spa*tʲ*	spa*t*	spa*fʲ*	to sleep
	n–nʲ	ˈadrʲe*s*	ˈadrʲe*sʲ*	ˈadrʲe*n*	address
	l–lʲ	zdʲe*sʲ*	zdʲe*s*	zdʲe*pʲ*	here
	r–rʲ	ekˈzamʲe*n*	ekˈzamʲe*nʲ*	ekˈzamʲe*t*	exam
		ˈosʲe*nʲ*	ˈose*n*	ˈose*lʲ*	fall
		sto*l*	sto*lʲ*	sto*r*	table
		so*lʲ*	so*l*	so*mʲ*	salt
		ˈsaxa*r*	ˈsaxa*rʲ*	ˈsaxa*t*	sugar
		sloˈva*rʲ*	sloˈva*r*	sloˈva*nʲ*	dictionary
Intervocalic:	t–tʲ	*gaˈzʲeta*	*gaˈzʲetʲa*	*gaˈzʲeba*	newspaper
VCV/VCʲV	s–sʲ	ˈtʲo*tʲ*a	ˈtʲo*t*a	ˈtʲo*rʲ*a	aunt
	n–nʲ	pʲiˈ*s*atʲ	pʲiˈ*sʲ*atʲ	pʲiˈ*r*atʲ	to write
	l–lʲ	ˈti*sʲ*atʃa	ˈti*s*atʃa	ˈti*mʲ*atʃa	thousand
	r–rʲ	ʒeˈ*n*a	ʒeˈnʲa	ʒeˈ*r*a	wife
		ˈta*nʲ*a	ˈta*n*a	ˈta*mʲ*a	Tanya (name)
		xoˈ*l*odnij	xoˈ*lʲ*odnij	xoˈ*s*odnij	cold
		zʲeˈ*lʲ*onij	zʲeˈ*l*onij	zʲeˈ*rʲ*onij	green
		ˈsʲe*r*ij	ˈsʲe*rʲ*ij	ˈsʲe*b*ij	gray
		ˈku*rʲ*itsa	ˈku*r*itsa	ˈku*dʲ*itsa	chicken