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ORTHOGRAPHIC LEARNING IN L1 AND L2 ALPHABETS: THE IMPACT OF PHONOLOGICAL INCONSISTENCY ACROSS CYRILLIC AND ROMAN SCRIPTS[4]

The acquisition of new orthographic representations has been systematically found as a fast and accurate process in monolingual readers. The present study aims to extended this research to biliterate and bialphabetic population, addressing the impact of phonological inconsistencies across the native (L1) and second (L2) alphabet. Naming latencies were collected from 50 Russian-English biliterates through a reading-aloud task, in which familiar and novel words were repeatedly presented across 10 blocks. The stimuli were equally divided in three script conditions: Cyrillic, Roman (in both cases, using script-specific graphemes) and ambiguous (using graphemes common to L1 and L2 alphabets, and thus phonologically inconsistent). Linear mixed-effects modelling revealed differences in the process of orthographic learning depending on the script. Thus, although naming latencies for novel and familiar words in the ambiguous condition were matched along the training, this effect was much faster in conditions of phonological consistency. Nonetheless, post-training outcomes of learning revealed similar recall and recognition performance in familiar and trained words regardless of the script. Overall, our results indicate that phonological inconsistency interferes with the decoding of novel words but does not prevent the efficient achievement of orthographic representations in biliterates.

JEL Classification: Z.

Keywords: Reading, orthographic learning, biliteracy, Cyrillic alphabet, Russian language

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Introduction

Orthographic learning refers to the ability of readers to establish novel word representations into their lexicon. This ability is considered to develop following an indirect, self-teaching manner, while the reader is exposed to novel written word-forms during independent reading; thus, throughout repeated phonological decoding (i.e. print-to-sound) of novel words, new specific representations are built for these stimuli, enabling its direct visual recognition in next encounters (Share, 1995; 2008). This mechanism, crucial for the acquisition of novel vocabulary in visual domain and for the development of efficient reading and communication skills, works rather efficiently. Indeed, several studies using different learning indices have systematically reported the acquisition of novel written word-forms after very short training, involving no more than ten exposures. Among these studies, some of them have reported changes on-line, during the process of orthographic learning, for instance in the reduction of the lexicality effect (thus, differences in naming latencies between novel and familiar words with representation at reader's lexicon, e.g. Salasoo et al., 1985) or, more commonly, the length effect (namely, the reduction in naming latencies between short and long novel words, e.g. Álvarez-Cañizo et al., 2019; Álvarez-cañizo et al., 2018; Kwok et al., 2017; Kwok & Ellis, 2015; Maloney et al., 2009). These results indicate the change in the reading strategy for trained words as a consequence of lexical representation, evolving from sequential decoding to whole-word visual recognition strategy. Some other studies, however, provide information regarding the access to such newly-acquired lexical representations, for instance in the better recall (through typing) or recognition (among novel, but non-trained foils) of these stimuli after the training (Cunningham et al., 2002; Share, 1999) or in the interference caused by these stimuli in the processing of orthographically-related familiar words (Bowers et al., 2005; Clay et al., 2007; Qiao et al., 2009; Qiao & Forster, 2013). In general, these findings indicate very fast and robust effects of orthographic learning, found across different languages (Álvarez-Cañizo et al., 2019; Suárez-Coalla et al., 2016), Italian (Paulesu et al., 2000), English (Tamura et al., 2017; Wang et al., 2012), Dutch (Martens & de Jong, 2008; de Jong & Share, 2007).

Importantly, the majority of studies reporting fast orthographic learning have been carried out in monolingual population, thus exploring the acquisition of novel words in L1 reading. However, as a consequence of growth in bilingual population, the amount of people able to master reading in a second language (i.e. biliterates) and thus to incorporate new vocabulary through L2 reading is growing rapidly. Moreover, often biliteracy implies managing a typologically different alphabet or script or even a different writing system. These phenomena raise the question whether decoding processes and hence acquisition of a new vocabulary through reading differs between L1 and L2 writing systems and scripts, and what are the factors that influence orthographic learning in these cases. In the past few years, the amount of research dedicated to investigation of the acquisition of reading skills in a second language has grown fast, reporting systematically cross-lingual transfer effects between L1-L2 orthographic systems (see Chung et al., 2019, and Lallier & Carreiras, 2018, for recent reviews). However, fewer studies have addressed reading and, particularly, orthographic learning skills in a second writing system or a second script. The present study aimed to shed some light onto this strand of research, by studying orthographic learning processes in a biliterate population, fluent in two different languages and scripts.

Since reading essentially consists of extracting or decoding of phonological information from the visual input, that is, to transform a written message into spoken language, reading across L1 and L2 orthographies should be rather similar; indeed, this core process is universal among writing systems (Perfetti, 2003; Share & Stanovich, 1997). However, the wide number of scripts (within and across different writing systems) and their variations in several aspects lead to incongruencies between the native and non-native scripts, which in turn contribute to affect both decoding and subsequent word learning in the L2 alphabet. In particular, writing systems and scripts can differ in terms of the visual complexity of the graphemic representations, from a small number of strokes and short size of the inventory, like in Spanish or Hebrew, to a much higher number of strokes and larger inventory sizes, like in Arabic, Indian Kannada or Chinese (Abdelhadi et al., 2011; McBride-Chang et al., 2011; Nag, 2007). In terms of the orthographic representation, this is, the unit of spoken language that is represented by visual symbols, from single phonemes, like in French or Russian, to syllables or morphemes, like in Korean or Japanese Kanji (Perfetti et al., 2002; Perfetti & Dunlap, 2008). In terms of the orthographic depth, namely, the regularity in the print-to-sound mappings, ranging from consistent, one-to-one mapping of symbols into sounds in transparent or shallow orthographies such as in Finish, Greek or Indian Devanagari, to inconsistent, one-to-many mappings in opaque orthographic systems, with the most extreme case in English language (Seymour et al., 2009; Ziegler & Goswami, 2005).

As a consequence of this disparity, efficient decoding and word learning in a second script depend on a number of challenging tasks. First of all, biliterates at different alphabets must learn the graphs or orthographic units specific in L2 script as well as their phonological correspondences, and secondly, manage the eventual inconsistencies between L1 and L2 scripts, meaning that a lower level of incongruency allows for better decoding and word learning outcomes. Thus, orthographic inconsistency between L1 and L2 scripts, in terms of the level of orthographic representation or orthographic regularity, leads to different reading strategies which in turns affect word learning in the non-native script (Hamada & Koda, 2008; Schwartz et al., 2014). For instance, in a study about novel word learning in Korean-English and Chinese-English biliterates, the decoding and recall of novel words in L2 English was found to be higher among the group of Korean than Chinese learners. This effect is explained by the higher consistency between Korean and English reading, since both follow phonological assembling of visual patterns, whereas Chinese, as a logographic language, is read in a non-segmented, holistic fashion (Hamada & Koda, 2008). Furthermore, the level of phonological inconsistency across alphabets, in terms of the symbol-to-sound correspondences carried out in L1 and L2 reading, could also play an important role in both decoding and word learning skills in the second script. However, the effects of phonological inconsistencies across L1 and L2 scripts, led by decoding of same visual symbols into different sounds across scripts, have been poorly studied so far, likely because of the lack of grapheme overlap across languages. Several studies, in contrast, have addressed the effect of orthographic overlap across languages within the same alphabet by means of cognates, namely, existing words that share orthographic form in both L1-L2 but differ in phonological decoding and meaning (Bultena et al., 2013; Cop et al., 2017; Peeters et al., 2013). In these studies, the overlap is found to produce a faster processing of cognates than non-cognate control words, reflecting a cross-lingual facilitatory effect lead by the co-activation of both target words at an integrated lexicon. Nonetheless, as orthographic cognates usually share high degree of phonological decoding (i.e. the cognate word piano is similarly decoded in English and Dutch), such effects may be rather different when the overlap involves phonological inconsistencies across languages and scripts. This argument is supported by few studies exploring the impact of the phonological incongruency across L1 and L2 scripts in visual word recognition (Havelka & Rastle, 2005; Lukatela, 1999; Lukatela & Turvey, 1990; Rastle et al., 2009). In these studies, mainly conducted in Servo-Croatian - English biliterates, L2 English words are systematically found to exhibit slower naming latencies when containing ambiguous or inconsistent graphemes, decoded into a different sound in L1, than those containing non-ambiguous, specific L2 graphemes. Such effect of phonological ambiguity is generally attributed to the application of two different and competing decoding rules for those graphemes but mapped into different sounds across alphabets.

These studies usually compare reading across Cyrillic and Latin or Roman alphabets, both alphabetic scripts which are characterized for having a considerable degree of graphemic overlap. Cyrillic script is used by a relatively large amount of readers in the world across many Slavic (such as Russian, Belarusian, Ukrainian, Servo-Croatian, Bulgarian or Macedonian) and non-Slavic languages (such as Tatar, Mongolian and Ossetic, among others). Importantly, this population is highly exposed to the Roman alphabet; indeed, very often this population has English, and thus Roman script, as their second L2 language, and a percentage of them also use the Roman script in their native languages, as is the case of Serbian. Regarding the overlap between Cyrillic and Roman scripts, although each alphabet has a certain number of script-specific or unique graphemes, thus present only in Cyrillic (i.e. ш, ж, ф, ч) or in Roman (i.e. v, q, z, f), several other graphemes are used in both scripts. Among these shared graphemes, some of them are mapped into the same phoneme both in Cyrillic and Roman alphabets (i.e. k, t, o, a), whereas others have a different mapping across scripts (i.e. the grapheme p, decoded as /p/ in Roman but as /r/ in Cyrillic, or the grapheme c, decoded as /k/ in Roman but as /s/ in Cyrillic). Although such phonological ambiguity has been demonstrated to affect the reading latencies among biliterate users of Cyrillic and Roman alphabets, this data has not been extended so far to other aspects of L2 reading, such as novel word learning. Taking into account the key role of phonological assembly in reading, especially in alphabetic languages such as English, it is reasonable to expect that inconsistent phonology across alphabets would impact both the decoding and representation of novel English words, affecting the acquisition of new vocabulary and therefore the efficient communication in L2 reading.

Therefore, the present study aimed to explore the orthographic learning processes in a group of Russian-English biliterates both in their native and non-native alphabets and, particularly, to clarify the influence that L1-L2 script overlap has in the decoding, formation and access to lexical memory traces for novel words. To do so, the effect of phonological inconsistency was disentangled from a mere effect of novel word learning under a second script by mean of a meticulous manipulation of the stimuli presented in L2 alphabet, namely either consistent or inconsistent with decoding rules in the native script. Novel words under different script conditions (Cyrillic, Roman and ambiguous) were repeatedly exposed under a reading aloud task together with familiar words and measures of orthographic learning were taken online, during the training, as well as offline by mean of different post-training tasks (recall and recognition tasks, providing a direct learning measure, as well as a lexical decision task, showing the interference when categorizing trained words as non-lexical items). Different research questions were formulated for the effect of phonological inconsistency, namely in relation to its impact in reading and decoding processes across the training of novel words as well as in relation to orthographic memory formation and retrieval. First, it was hypothesized that the decoding of novel words would be affected by phonological inconsistencies lead by the overlap across L1 and L2 alphabet, which in turn would interfere with the orthographic representation of these stimuli. As a consequence, novel L2 words with inconsistent graphemes were expected to exhibit higher naming latencies across their training as well as lower reduction of lexical differences with familiar words, in comparison to novel L2 words with graphemes consistently decoded across L1 and L2 alphabets. Accordingly, it was expected that new orthographic representations acquired under phonological ambiguity would be poorly accessed at post-training assessment. In contrast, a general effect of native alphabet was expected, with better decoding and orthographic representation for novel words presented in L1 Cyrillic script.

Materials and Methods

Participants

50 participants (23 females, aged between 18 and 30 years old, Mage = 20.8, SD = 2.78) took part in the experiment. All participants were right-handed, native Russian (L1) speakers with normal or corrected-to-normal vision and no history of cognitive, neurological or psychiatric disorders. All of them had English as their second language (L2), with different levels of proficiency at speaking and reading in this language; 34 of them were also speakers of other languages (L3)[5]. The study was approved by the Ethics Committee of the Department of Psychology, National Research University Higher School of Economics.

Stimuli

The experimental stimuli consisted of 24 familiar and novel words, equally divided into L1 Cyrillic (i.e.: “шаг”, “шаз”), L2 Roman (i.e.: “vet”, “vaz”) and a self-created ambiguous script condition (i.e.: “cop”, “pex”). Therefore, 12 familiar words were presented in Cyrillic (4), in Roman (4) or in the ambiguous (4) script, and the same was done for 12 novel words. All stimuli were 3 letters length with a Consonant-Vowel-Consonant (CVC) structure. Novel words were constructed maintaining the first letter of a familiar word in the corresponding script condition. In addition, stimuli presented in L1, L2 and ambiguous conditions were matched across each group of familiar and novel words in log trigram frequency (paired tests carried out using nonparametric Mann-Whitney-Wilcoxon confirmed no differences across conditions, p<.05). See Table 1 for log frequency means at each experimental condition. Trigram frequency values for stimuli at both L1 and L2 were taken from Russian National corpus (http://www.ruscorpora.ru/new/search-main.html) and British National Corpus (https://www.english-corpora.org/bnc/) online databases, respectively. Stimuli used in the study can be found in the Appendix.

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[5] German n=19, French n=11, Spanish n=6, Latin n=4, Italian n=3, Ukrainian n=3, Arab n=2, Armenian n=1, Chinese n=1, Swedish n=1, Indonesian n=1, Czech n=1, Belorussian n=1, Danish n=1

Tab. 1. Means of log trigram frequencies for each condition of familiar and novel words presented in different scripts.

	Cyrillic	Roman	Ambiguous (Cyrillic)	Ambiguous (English)
Familiar Words	2.12	2.08	2.53	1.98
Novel Words	-0.74	-0.21	-0.12	0.29

Note: for stimuli presented in ambiguous script, trigram frequencies were matched considering both in Cyrillic and Roman scripts

Importantly, stimuli in Cyrillic and Roman scripts were built by graphemes specific of each alphabet, as well as by graphemes common to both and mapped into the same phonemes, hence phonologically consistent across scripts. However, in the ambiguous condition, stimuli were created by combining common and consistent graphemes with common but inconsistent graphemes, namely used in both Cyrillic and Roman alphabets but decoded into a different sound depending on the script (i.e.: the grapheme “p” is decoded as /p/ in Roman but as /r/ in Cyrillic, and the grapheme “x” is decoded as /x/ in Roman whereas as /j/ in Cyrillic). In order to ensure the ambiguity of the stimuli in the ambiguous condition, special handwriting fonts were used in the study enabling the presentation of the stimuli in italics (see Appendix 1). In this way, for instance, the letter "п" (decoded in Russian as /p/) and the letter "n" (decoded in English as /n/) looked exactly the same, thus resembling the ambiguity in the decoding of particular Roman characters. In particular, the font “Notperfect regular” was used for all stimuli letters except for “t” and “т”, which were presented in italic “Swanky and Moo Moo Cyrillic” font. The letter “q” was manually edited to make it more discriminable from the letter “g” (see Appendix 1). The same handwriting style font was used for both the training and post-training tasks, including the instructions provided on them.

In addition, another set of stimuli was selected as foils for the recognition and lexical decision tasks carried out in the post-training phase. Thus, for each task, 48 untrained stimuli were constructed (2 foils per each previously trained stimulus), maintaining the first two letters of the corresponding stimulus in the training task. In both tasks, these stimuli were presented together with those presented in the training task.

Procedure

The duration of the whole study was approximately one hour. Participants underwent two different phases during the study, first a training phase, consisting of a reading aloud task, and second a post-training phase, with recall, recognition and lexical decision tasks. Before starting the training phase, participants also completed the full version of the Leap Questionnaire (Marian et al., 2007), in order to determine whether their level of English proficiency and exposure explain their performance during the training.

During the training phase, participants were asked to read aloud as fast an accurately as possible the set of 24 familiar and novel words, repeatedly presented across 10 different blocks (see Figure 1 for experimental sequence). The stimuli were presented in black font over a grey background at the centre of a computer screen by means of E-prime software (Psychology Software Tools, Inc., Schneider et al., 2002). A headset Microsoft LifeChat LX-3000 (with noise-canceling microphone) was used to collect participant's utterances for each stimulus. The presentation of the stimuli was pseudorandomized within each block and participant in order to prevent the presentation of two consecutive stimuli from the same condition. Moreover, given that the previous presentation of an L1 or L2 stimuli could affect the pronunciation of an ambiguous stimulus (in English or in Russian), each trial included a distractor (a white or a black rhombus) presented between target stimuli (see Figure 1). Participants had to decide the color of the rhombus by pressing a corresponding key in the keyboard with their right (L) or their left finger (D). Keys were labeled with a corresponding color sticker. The color of distractor stimuli was randomized across trials and responses were counterbalanced across participants (namely, half of them responded to white color with their right index finger and black with their left index finger whereas the other half did the opposite). Before starting the training task, participants were presented with 12 practice trials (2 trials per condition) using the same experimental sequence. During the training, participants took two breaks (after 4th and 7th blocks) in order to avoid fatigue.

Immediately after completing the reading-aloud task, participants underwent the post-training phase of the study, starting with a recall task in which they were asked to write down all stimuli they could remember from the previous training phase. Answers were collected on a paper sheet with 30 spaces to fill, with no time restriction. Immediately after, participants carried out the recognition and the lexical decision tasks in subsequent order and with the same procedure and stimuli. In particular, stimuli previously presented at the training phase were presented in these tasks together with foils. Stimuli were presented in randomized order at the centre of a computer screen by means of E-prime software. Participants were asked to press a button on a keyboard (D or L, labeled with a white or a black sticker) to decide whether the stimuli had been previously presented in the training phase or not (in the recognition task) and to categorize the stimuli as real words or as non-words (in the lexical decision task). For half of the participants, D button was labeled with a white sticker and L button with a black sticker, opposite for the other half; moreover, half of them pressed white for those stimuli previously trained and black for those non-previously trained, whereas the other half did the opposite. Time for responses was not limited and both latency and accuracy were collected in both tasks.

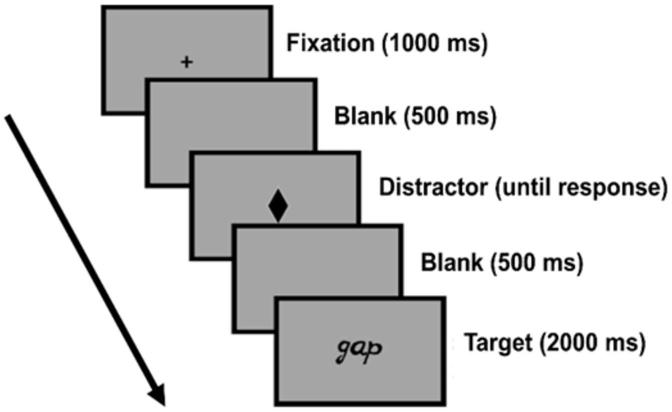

Fig. 1. Sequence of stimuli presentation during the reading-aloud task (training phase).

Data analysis

Training phase

Reading latencies obtained at the reading aloud task were extracted manually for each trial and participant using Praat software (Boersma, 2011). Utterances containing errors (i.e.: no response, incorrect pronunciation, hesitations or mix of alphabets in ambiguous stimuli) were excluded from the analysis. Responses below or above 2 standard deviations were also rejected. The ambiguous nonword stimulus “сик” (“cuk”) was also excluded from the analyses because this stimulus was pronounced in Russian in 99.6% of cases. In order to determine the effect of learning through the training blocks across different scripts of presentation, an analysis using mixed-effects modelling was carried out. This method enables to estimate random effects not explained by experimental variables but caused by random variation between participants or items, thus effectively separating the fixed effects of predictor variables (Baayen et al., 2008; Barr et al., 2013;). The analysis was conducted in R software (Team, 2013) using the lmer function and lmerTest packages (Kuznetsova et al., 2017). In particular, the block (from 1 to 10), lexicality (familiar and novel words) and script (Cyrillic, Roman and Ambiguous) were entered in the analysis as predictor variables (fixed effects), participants and items as random effects and the RTs as the dependent variable. An additional linear regression analysis was carried out in order to determine whether the effectiveness of the training (showed in the naming latencies obtained for novel words at the end of the exposures) were explained by the level at proficiency, age of acquisition and exposure to of participants to English, using the measures obtained from Leap-Questionnaire (see Supplementary material).

Post-training phase

For the recall task, the number of correct recalled stimuli across each condition and participant was calculated and converted into to a percentage scale. This data was analyzed by using mixed-effects modelling with script (Russian, English and Ambiguous) and lexicality (familiar and novel words) as predictors (fixed effects) and the participants as a random effect.

Regarding recognition and lexical decision tasks, only correct responses were entered in the analysis. Corresponding foils for the stimulus "сик" ("cuk") were eliminated together with this stimulus from the analysis of data resulting from the recognition task. Since in these tasks participants had no time limit to response, all responses below 500 ms and above 2500 ms were excluded from the analysis. Then, in a second step, the remaining RTs were logged and standard deviations were calculated for each condition. Those response times below or above 2 standard deviations were excluded from the analysis. Mixed-effects model analysis were conducted with familiarity (trained, non-trained foil), script (Russian, English and Ambiguous) and lexicality (familiar and novel words) as fixed effects and item and participant as random effects.

Results

Training phase

From the total amount of responses obtained from participants during the reading aloud task, 2.33% contained errors and were discarded from the analysis; another 4.16% of outliers was also rejected. See Table 2 with final dataset, showing the main means obtained by block (first and tenth), lexicality (familiar and novel words) and type of script (Cyrillic, Roman and ambiguous). Using LME analysis the best model (lowest AIC—Akaike's Information Criterion) resulted in the interaction RT ~ Block × Lexicality × Script + (1|Item) + (1|Participant) ($\chi2(30)=199.6$, $p<.001$). The ANOVA conducted for this model reveled statistically significant main effects of block (F(9,11093)=130.73, p<.001), as naming latencies significantly decrease across the training (Block 1: M=832; Block 10: M=634), lexicality (F(1, 17)=20.86, p<.001), given novel words showed higher naming latencies (M=738) than familiar words (M=663) and script (F(2,17)=39.37, p<.001), with naming latencies differing depending on the alphabet of presentation (Cyrillic: M=606; Roman: M=711; Ambiguous: M=784). We also found significant interactions between block x script (F(18,11093)=4.99, p<.001), block x lexicality (F(9,11093)=17.64, p<.001) and marginally lexicality x script (F(2,17)=3.25, p=.063); importantly, the three-way interaction block x script x lexicality was also found significant (F(18,11093)=1.77, p=.022).

Tab. 2. Mean and standard error of naming latencies (RTs) by each condition of lexicality and script at the first and the tenth block of the training task.

	Block 1		**Block 10**	
	Familiar words	**Novel words**	**Familiar words**	**Novel words**
Cyrillic	632 (26.3)	761 (26.4)	552 (26.4)	575 (26.3)
Roman	809 (26.4)	936 (26.4)	628 (26.3)	651 (26.4)
Ambiguous	789 (26.3)	1068 (29.7)	666 (26.3)	735 (29.6)

Thus, the three-way block x lexicality x script revealed that repeated exposures across the ten training blocks caused a decrease in the differences between familiar and novel words, although differently depending on the script of presentation. Post hoc analyses were carried out in order to explain the three-way interaction. First, the effect of the script in the naming latencies of familiar and novel words was explored across the training blocks. In general, the impact of the script was found higher in the naming latencies of novel (F(2,8)=25.52, p<0.001) than of familiar words (F(2,9)=14.10, p<0.001). The interaction lexicality x script was found marginally significant at the beginning of the task (F(2,16.94)=2.87, p=.08) whereas this interaction was not found at the end of the training (F(2,17.205)=0.99, p=.39). Thus, in the beginning of the training, novel words showed higher naming latencies when read in non-native, Roman script (estimate=174.94, SE= 34.0, p<0.001) and, particularly, when presented in ambiguous script in comparison to those read in native Cyrillic (estimate=307.75, SE= 36.9, p<.0001). However, for familiar words, the initial impact of the orthographic script in naming latencies was similar when presented in Roman (estimate=176.91, SE=30.1, p<.0001) or in ambiguous script (estimate=156.92, SE=30.1, p<0.001) in comparison to Cyrillic. Nonetheless, at the end of the training, familiar and novel stimuli did not show a different impact on their naming latencies depending on the script of presentation; hence, after the training (block 10) novel words in Roman script showed similar naming latencies as those presented in Cyrillic (estimate=75.97, SE=33.9, p>.05), with a similar pattern found for familiar words (estimate=75.90, SE=30.2, p>.05). In a similar way, novel words trained in non-native, ambiguous script still showed higher naming latencies in comparison to those presented in L1 alphabet (estimate=160.99, SE= 36.8, p=.005) as similarly found for familiar words (estimate=114.40, SE=30.1, p=.042). Thus, novel words exhibited higher influence by the ambiguity of the script at the beginning of the training in comparison to familiar words whereas such impact was found reduced at the end of the training. Figure 2 shows the pattern of reading latencies through the training blocks for familiar and novel words presented in Cyrillic, Roman and ambiguous alphabets.

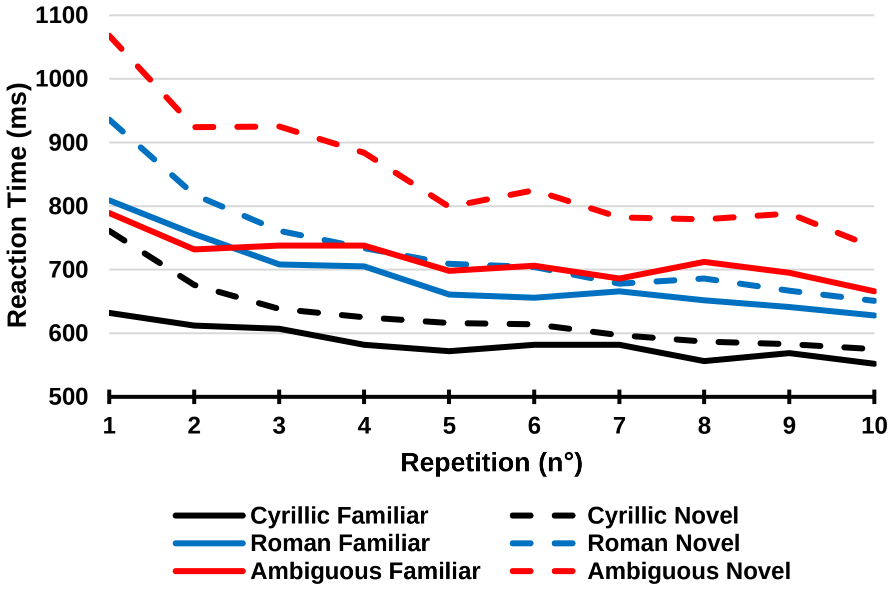

Fig. 2. Mean naming latencies (RTs) obtained across training blocks for each experimental condition (familiar and novel words in Cyrillic, Roman or ambiguous script).

Furthermore, differences between familiar and novel words in different training blocks were explored across the three different scripts. The interaction block x lexicality was found significant across the three scripts, although higher at Cyrillic (F(9,3879)=7.59, p<.001) and at ambiguous script (F(9,3253.2)=7.66, p<.001) than at Roman alphabet (F(9,3863)=4.31, p<.001) and the effect of the training was found, in general, higher in novel (F(9,5210.1)=100.47, p<.001) than in familiar words (F(9,5834)=34.18, p<.001). Follow-up comparisons for the effect of block across the three scripts revealed that, for familiar words, the highest decrease in latencies across the ten exposures was found in Roman (Estimate=180.96, SE=16.0, p<.001) followed by the ambiguous script (Estimate=122.47, SE=15.9, p<.0001) and the native alphabet (estimate=79.95, SE=15.9, p<.001). However, for novel words, the highest reduction in naming latencies was found for those presented in the ambiguous (Estimate=333.39, SE=21.9, p<.001) and in Roman (Estimate=285.59, SE=18.3, p<.001) followed by those presented in L1 Cyrillic (Estimate=186.63, SE=18.2, p<.001). Such different pattern in the decrease of naming latencies for novel and familiar words caused a different reduction of the lexicality across scripts (see Table 3). Although initial differences for familiar and novel stimuli in the beginning of the training (F(1,16.95)=40.89, p<.001) were found reduced at the end of the task (F(1,17.21)=6.38, p=.021), this reduction was faster in non-ambiguous conditions of Cyrillic and Roman alphabets than in the ambiguous script condition. Thus, lexical differences found in the beginning of the training in the native (Estimate=129.14, SE=29.6, p=.002) and in the Roman script (Estimate=127.77, SE=35.1, p=.036) have been eliminated already by the second presentation (for the native Cyrillic script, estimate=63.88, SE=29.6, p=0.82; for the non-native, Roman script, Estimate=23.73, SE=35.1, p=1), and importantly, maintained throughout the rest of the blocks. However, initial differences between familiar and novel words presented in the ambiguous script (Estimate=278.50, SE=33.1, p<.001) were eliminated later on, at the fifth presentation (Estimate=104.29, SE=33.2, p=0.16); moreover, such lexical differences were revealed again at the sixth exposure (estimate=120.72, SE=33.0, p=0.034) although disappeared at the seventh presentation (Estimate=95.81, SE=33.0, p<.28).

Post-training phase

Recall task

Using LME analysis, the best model (lowest AIC—Akaike's Information Criterion) found was Accuracy ~ Script + (1|Participant) ($\chi2(1)=41.62$, p<.001), revealing recall differences between the stimuli depending on the script of presentation at the training. The ANOVA conducted for this model confirmed a statistically significant effect of script (F(2,248)=22.464, p<.001). Pair-wise comparisons revealed significant differences across the three alphabets, with better recall rates for stimuli presented in the ambiguous script (59.4%) than those presented in non-native Roman (47.7%, Estimate=11.7, p=.002) or native Cyrillic alphabet (36.5%, Estimate=22.9, p<.001); moreover, recall scores also differed between L1 and L2 scripts, with the lowest percentage of correctly recalled stimuli found in the native alphabet (Estimate=11.2, p=.003). See Figure 3A for the average percentage of recall across conditions.

Tab 3. Lexicality effect obtained for each script condition and block across the training task.

	Cyrillic		**Roman**		**Ambiguous**	
	Estimate	***p* value**	**Estimate**	***p* value**	**Estimate**	***p* value**
Block 1	129.1419	.0021**	127.7755	.0361*	278.500	<.0001***
Block 2	63.8868	.8244	62.9583	.9637	190.615	<.0001***
Block 3	31.4445	1.0000	54.4698	.9926	186.153	<.0001***
Block 4	42.6212	.9970	29.6523	1.0000	149.724	.0011**
Block 5	44.0757	.9955	48.3973	.9983	104.290	.1622
Block 6	31.2225	1.0000	48.6342	.9982	120.726	.0341*
Block 7	14.4720	1.0000	11.7674	1.0000	95.813	.2868
Block 8	31.0313	1.0000	34.6042	1.0000	69.674	.8517
Block 9	14.2530	1.0000	25.9136	1.0000	91.925	.3539
Block 10	23.4620	1.0000	23.7383	1.0000	67.549	.8828

***<.0001

**<.01

*<.05

Recognition task

From the total amount of responses obtained, 8.36% was discarded from the analysis due to errors and another 5.64% of responses were rejected as outliers. LME analysis in the final dataset revealed the best model (lowest AIC—Akaike's Information Criterion) as RT ~ Familiarity × Lexicality + (1|Item) + (1|Participant) ($\chi2(0) = 19.7$, p<.001). The ANOVA carried out for this model revealed significant effects of familiarity (F(1,58.47) = 12.06, p < .001), showing lower recognition latencies for trained (M=929) than for non-previously trained stimuli (M=1026) and lexicality (F(1,58.42)=12.33, p<.001), with lower recognition latencies for familiar (M=928) than for novel words (M=1026), regardless of the script of presentation. The interaction between familiarity and lexicality resulted marginally significant (F(1,58.43)=3.63, p=.061), suggesting that whereas familiar words showed similar recognition latencies independently on whether these stimuli received previous training or not (Estimate=43.68, SE=38.5, p>.05), novel words were recognized significantly faster when trained than when these stimuli were not previously trained (Estimate=149.93, SE=40.3, p<.005). Thus, similar recognition times were exhibited by familiar and novel words previously trained (Estimate=44.77, SE=45.4, p>.05), whereas lexical differences were found between familiar and novel words non-previously trained (Estimate=151.01, SE=32.4, p=.0001). See Figure 3B.

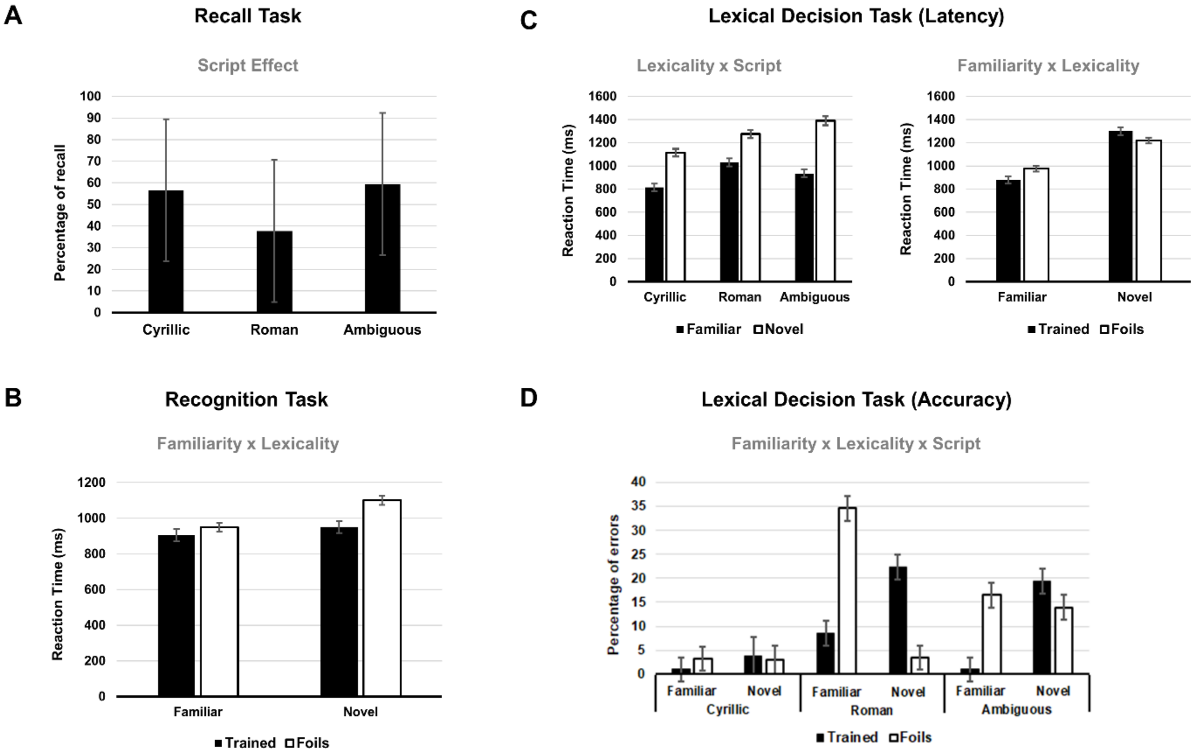

Fig. 3. Results across the three post-training tasks carried out in the study: recall (A), recognition (B) and lexical decision task (C, results on latency data and D, on accuracy data).

Lexical decision task

In this task, 13.07% of data contained errors and thus was discarded from analysis on RTs; another 15.93% of outliers were rejected. The analysis on RTs with the final dataset revealed the best model (lowest AIC—Akaike's Information Criterion) as: RT ~ Familiarity × Script × Lexicality + (1|Item) + (1|Participant) ($\chi 2(6) = 98.28$, p<.001). The ANOVA carried out for this model revealed main effects of script (F(2,52.42)=28.46, p<.001), indicating higher reaction times for stimuli presented in ambiguous (M=1162) and Roman (M=1152) than in Cyrillic alphabet (M=963) and lexicality (F(1,53.03)=176.32, p<.001), revealing higher response latencies for novel (M=1259) than for familiar words (M=926). We also found significant interactions of script × lexicality (F(2,52.343)=5.83, p=.005) and familiarity × lexicality (F(1,52.68)=12.56, p<.001). No effects or interactions were found (p>.05).

Post hoc analyses were carried out in order to explain both significant interactions. Regarding script x lexicality interaction, we found that novel words showed higher RTs than familiar words when presented in ambiguous script (Estimate=454.7, SE=46.6, p<.001) than in Cyrillic (Estimate=299.9, SE=40.5, p<.001) and Roman (Estimate=244.6, SE=42.9, p<.001) scripts. On the other hand, novel words showed higher reaction times when presented in non-native alphabet than when presented in the native alphabet, both in Roman (Estimate=161.2, SE=41.6, p=.003) and, particularly in ambiguous script (Estimate=276.4, SE=46.5, p<.001); however, only familiar words presented in Roman script exhibited higher reaction times than in Cyrillic (Estimate=216.5, SE=41.9, p<.001), since no differences were found when categorizing familiar words in ambiguous or Cyrillic (Estimate=121.5, SE=40.7, p=.47). See Figure 3C. Regarding the interaction familiarity x lexicality, we found that familiar words showed faster reaction times when previously presented at the training task than when not previously presented (Estimate=96.7, SE=33.9, p<.03), whereas novel words exhibited similar reaction times independently on whether these stimuli were previously trained or not, although RTs were slightly higher for trained than for foils (Estimate=-80.8, SE=36.8, p=.13). See Figure 3C. As a result, differences between novel words and familiar words were higher when these stimuli were previously trained (Estimate=421.8, SE=40.7, p<.0001) than when stimuli received no previous training (Estimate=244.4, SE=29.3, p<.0001).

Given the relatively high percentage of errors in this task (13.07% of the total amount of responses), LME analyses were also conducted on accuracy data. The best model was found as error percentage ~ Familiarity × Script × Lexicality + (1|Participant) ($\chi2(6)$ = 114.17, p<.001). The ANOVA conducted in this model revealed main effects of familiarity (F(1,536.05)=4.71, p=.03), since higher percentage of error was obtained for foils (M=12.43) than for trained stimuli (M=9.34) and script (F(2,536.41)=36.17, p<.001), given that in general higher percentage of error was found for categorization of Roman (M=17.22%) and ambiguous (M=12.69%) stimuli than for those in Cyrillic script (M=2.75%). In addition, significant interactions were found between familiarity x lexicality (F(1,536.05)=65.07, p<.001), script x lexicality (F(2,536.41)=11.40, p<.001) and familiarity x script x lexicality (F(2,536.05)=18.27, p<.001). No effect of lexicality or interaction between familiarity x script were found (p>.05).

Post hoc analyses were carried out to disentangle the three-way interaction. First, the interaction familiarity x lexicality was found significant at both Roman (F(1,147)=59.36, p<.001) and ambiguous (F(1, 144.14)=13.70, p<.001) scripts but not at the native Cyrillic alphabet (F(1,196)=1.39, p=0.28). In general, the effect of familiarity was found significant both in familiar (F(1,245)=89.64, p<.001) and novel words (F(1,242.46)=14.91, p<.001). Follow-up comparisons for the effect of familiarity across the three scripts revealed that, for familiar words, foils exhibited significantly higher error rate than previously trained words both in Roman (estimate=26.10, SE=2.67, p<.001) and ambiguous script (estimate=15.47, SE=2.47, p<.001), whereas in Cyrillic no differences were found between trained and foil words (estimate=2.19, SE=2.67, p>.05). However, a different pattern of results was found for novel words, which exhibited higher error rates when these stimuli were previously trained than when presented for the first time, thus reflecting an interference effect when categorizing trained words as non-lexical items, although this result only reached significance in Roman script (estimate=-18.88, SE=3.74, p<.001) but not in ambiguous (estimate=-5.39, SE=3.8, p>.05) or Cyrillic alphabets (estimate=-0.86, SE=3.74, p>.05). See Figure 3D. On the other hand, although error rates were generally found higher for novel words than for familiar words, such differences were higher when these stimuli were foils, presented to participants for the first time (F(1,243.97)=38.33, p<.001) than when previously trained (F(1,243.76)=28.10, p<.001). Follow-up comparisons for the effect of lexicality across scripts revealed that, when previously trained, novel words showed significantly higher error rates than familiar ones, in ambiguous (estimate=18.39, SE=3.85, p<.001) and Roman (estimate=13.83, SE=3.63, p=.004) but not in native Cyrillic script (estimate=2.83, SE=3.8, p>.05). However, when not previously trained, the contrary pattern was found, with familiar words showing higher error rates than novel words, although this effect only reached significance when presented in Roman (estimate=-31.14, SE=3.15, p<.001) but not in the ambiguous (estimate=-2.52, SE=3.17, p>.05) or Cyrillic alphabets (estimate=-0.21, SE=3.15, p=1).

Discussion

The present study aimed to investigate the process of orthographic learning under the native and non-native alphabets and, particularly, to determine the impact of phonological inconsistency ─as lead by graphemic overlap across L1 and L2 scripts─ in this process. We conducted training and post-training tasks to evaluate the decoding, orthographic representation and posterior access to novel written word-forms in a group of Russian-English biliterates, manipulating the amount of phonological inconsistency of the stimuli presented. In general, results found in this study point out that phonological inconsistency interferes with the decoding and reading automatization of novel word-forms across their training; however, this effect did not prevent the formation, although slower, of orthographic representations for these stimuli, enabling similar level of recall and recognition than the observed for familiar words at post-training tasks. In what follows, both patterns of results are discussed in detail.

The short training carried out in this study (involving just ten exposures), caused a fast automatization in the decoding of the novel word-forms, either presented in L1 or L2 alphabets, a result in agreement with previous findings obtained in similar training tasks reporting online measures (Álvarez-Cañizo et al., 2019; Álvarez-cañizo et al., 2018; Kwok et al., 2017; Kwok & Ellis, 2015; Maloney et al., 2009; Salasoo et al., 1985). Thus, naming latencies exhibited by these stimuli progressively decreased across their exposures to the extent that, at the end of the training, were matched to those exhibited by familiar words. Nonetheless, the improvement in the decoding and acquisition of orthographic representation for these stimuli actually depended on the phonological ambiguity of their grapheme-to-phoneme correspondences. Thus, those novel L2 words whose reading consisted in the decoding of ambiguous graphemes showed considerably higher naming latencies than those containing specific L1 or L2 graphemes, in Cyrillic or Roman alphabets. However, such ambiguity effect was mainly found at the beginning of the training, when these stimuli where unfamiliar, but significantly reduced at the end of the task, since the differences in the naming latencies of novel words across scripts resulted in a much smaller change. This result suggests that the orthographic familiarity of the stimulus, gained through repeated exposures, softened the impact of the phonological inconsistency in their naming. In the same vein, the impact of the phonological ambiguity was found much more pronounced for novel than for familiar words, as similarly found in previous studies testing this effect in high and low frequency words (Havelka et al., 2005; Lukatela et al., 1999) and, importantly, only at the beginning of the training. This result suggests that at that early stage, the decoding of novel stimuli followed a serial, grapheme-by-grapheme correspondence, and hence particularly affected by the ambiguity in decoding processes. However, as long as these stimuli gained orthographic familiarity across the training, and thus representation in reader´s lexicon, the impact of phonological ambiguity decreased; indeed, at the end of the training, novel and familiar L2 words were found to be similarly affected by the inconsistency of their grapheme-to-phoneme correspondences, indicating that novel words followed a reading strategy less dependent on phonological decoding but on the direct access to their newly-acquired orthographic traces.

Such acquisition of orthographic representation for those novel L2 words with ambiguous graphemes was directly observed both in online and offline training measures. First, in the elimination of the lexicality effect for these stimuli at the end of the training, an effect considered to reflect differences in the processing of familiar, already lexicalized words and those unfamiliar entrances, with no lexical representation (e.g. Forster & Chambers, 1973). Thus, the initial differences in naming latencies between novel and familiar ambiguous words were found to be eliminated at the end of the training, due to the significant speed-up in the reading of novel words across their exposures. Therefore, this result likely points out to the establishment of the newly-trained ambiguous L2 words in the orthographic lexicon regardless of the inconsistencies in their decoding, enabling its parallel, whole-form processing. Secondly, findings obtained at post-training tasks also confirmed the efficient establishment and access to mental representations for novel words in ambiguous script; thus, these stimuli showed similar performance than familiar words both at recall and recognition tasks, despite the ambiguity in their grapheme-to-phonemes correspondences. Moreover, ambiguous novel words were better recognized than other novel ambiguous words presented as foils, thus non-previously trained, a result indicative of orthographic learning and similar to those reported in previous studies using orthographic choice tasks (Cunningham et al., 2002; Share, 1999). Furthermore, results obtained at the lexical decision task also suggest the representation of trained novel words regardless of the phonological inconsistency in their decoding. Thus, these stimuli exhibited higher reaction times and error rates than those novel words non-previously trained; although significance was not reached in the ambiguous script, the pattern of results obtained at both contrasts indicated an interference during the categorization of previously trained-words as non-lexical items, hence resembling some level of lexicalization for these stimuli, not reached for non-previously trained foils.

Overall, these results demonstrate that, although phonological ambiguity interferes with the efficient decoding of novel words, such effect does not prevent the successful word representation into reader's orthographic lexicon along the training. Thus, these findings partially contradict our initial hypotheses, since we predicted poor achievement of orthographic learning for novel L2 words with ambiguous graphemes, differently mapped across L1 and L2 alphabets. Nonetheless, the effect of orthographic representation for ambiguous words must be examined carefully across the training. In this way, the build-up process of orthographic representations was actually interfered and delayed for these stimuli, as reflected in changes in the lexicality affect obtained across the alphabets. Thus, whereas novel words presented in consistent L1 and L2 scripts matched the naming latencies for familiar words particularly fast ─already at their second exposure─, those L2 novel words presented under an ambiguous script only reached the naming latencies for familiar words at their fifth presentation, and actually, such representation was not found stable until their seventh exposure. Such effect of phonological inconsistency in the orthographic learning of novel words is not surprising, taken into account the critical role of phonological decoding in the acquisition of reading as well as in novel word learning, as particularly evident when this skill is limited or impaired (Kyte & Johnson, 2006; Perfetti, 2003; Share & Stanovich, 1997). However, once an orthographic representation was built-up for these stimuli, the effect of such inconsistency remained at the level of that observed for familiar, already represented word-forms, and indeed, the memory traces acquired were stable and successfully accessed after the training. Importantly, these results provide for the first time evidence of the impact that phonological inconsistencies across L1 and L2 alphabets has in the acquisition of new vocabulary through L2 reading.

The successful achievement of orthographic learning for L2 novel words under conditions of phonological inconsistency could be tentatively explained by the availability of two different reading strategies for these stimuli, each corresponding to their decoding in L1 and L2 alphabets. Such ambiguity forces the reader to choose one of the strategies for decoding, and actually making more effortful the processing of these stimuli and increasing the attentional resources allocated to their reading. Although this results in the increase in naming latencies for these stimuli it might lead to their deeper encoding in reader's memory. The script effect obtained in the recall task is in agreement with this idea, as showing better retrieval of stimuli with ambiguous grapheme-to-phoneme decoding (either familiar and novel), in comparison to those presented in consistent Cyrillic or Roman graphemes; this suggests stronger orthographic representations for items whose reading is possible following two different decoding strategies. Therefore, although the knowledge of two alphabets interfere with the efficient phonological decoding of stimuli with ambiguous correspondences across alphabets, it seems to contribute to their better memory and learning, particularly to the encoding and access to their memory traces. This idea is in agreement with previous studies claiming for the key role of biliteracy in reading and novel word learning, the so-called biliteracy advantage. In these studies, biliterate show better orthographic learning than bilingual monoliterates learners, likely as a consequence of the higher flexibility of their orthographic systems (Kahn-Horwitz et al., 2014; Modirkhamene, 2006; Schwartz et al., 2007, 2014). However, whereas in these studies the facilitation is based on the transfer of orthographic characteristics across languages, in the present research the advantageous seems derived from the inconsistencies across orthographic scripts, which lead to higher control and monitoring of decoding processes and, consequently, stronger encoding of novel words. Nonetheless, the question of whether inconsistencies across overlap alphabets could actually lead to advantages in orthographic learning should be further explored in future research, by direct comparison of mono and biliterate population.

Regarding the process of orthographic learning under conditions of phonological consistency, results found in this study confirmed the effective acquisition of orthographic learning for novel words with non-ambiguous graphemes, either in the native and non-native alphabets. In this sense, naming latencies for novel words both in Cyrillic and Roman scripts decreased significantly across their training and matched those obtained for familiar words very fast, already at their second exposure, resembling similar reading automatization in native and non-native scripts. Moreover, in both alphabets, the performance for novel words did not differ from the exhibited by familiar words in recall and recognition tasks, indicating efficient access to newly-formed memory traces after training. These results confirm previous findings in biliterate population, reflecting the fast acquisition of new vocabulary through L2 reading (Chung et al., 2019; Schwartz et al., 2014; van Daal & Wass, 2017). Importantly, the present study extends these findings by addressing this topic in bialphabetic population and comparing orthographic learning under the native and non-native scripts, highlighting the role of phonological inconsistencies in this process. Nonetheless, more investigation is needed to further understand reading and novel word learning processes in biliterate population, particularly in regard to the underlying brain mechanisms that support the successful representation of novel words even in conditions of phonological inconsistency.

It must be noted that, as expected, stimuli presented in the native alphabet actually exhibited better reading performance than those presented in non-native Roman script. In this sense, novel words in Roman alphabet showed, despite of their training, slower naming latencies as well as slower lexical categorization and worse recall performance than those in Cyrillic script. Such effect of second alphabet is particularly expectable in this study, taking into account that our sample consisted of unbalanced Russian-English biliterates, who learnt English ─and hence Roman alphabet and its specific decoding rules─ only during their late childhood, as reflected by the high AoA of English language exhibited by this population (mean=7.82, range=13); consequently, the level of proficiency as well as exposure to both languages and scripts resulted also unbalanced, higher in Russian than English. A different pattern of results, however, could be expected in a group of early biliterates, with higher balance in the acquisition of decoding skills among the native and non-native scripts and therefore higher reading proficiency at the second alphabet. In those conditions, would be reasonable to expect not only a lower effect of reading at a second alphabet but also a reduced impact of the phonological inconsistency across scripts, leading to more efficient word learning and communication skills in the second alphabet. Indeed, results from complementary regression analyses partially supported this idea (see supplementary material section), given that the higher the level of proficiency and exposure to English language, the better resulted the decoding performance for L2 stimuli after their training, both at consistent and inconsistent script conditions. This question must be addressed in more detail in future research, by comparing orthographic learning skills across early and late bialphabetic learners.

As a final remark, the present research provides empirical evidence about the decoding and orthographic learning skills in Russian and particularly in Cyrillic script. Since this language is highly similar to many other alphabetic languages in terms of orthographic representation and depth, results reported here contribute not only to the further investigation of Russian language but, importantly, to the generalization to other languages. Indeed, the majority of studies addressing orthographic learning and related topics are conducted in English, despite the fact that this language has several characteristics that make it an outlier in comparison to many other languages across the world (namely, its extreme orthographic depth) and that make difficult the generalization of results (Seymour et al., 2009; Share, 2008; Ziegler & Goswami, 2005). Thus, the present study extends this research, providing evidence for decoding and novel word learning process in a rather transparent orthography, comparable to many other languages and scripts within the family of alphabetic systems.

Supplementary material

In order to determine whether the naming latencies obtained for novel words at the end of the training were explained by the level proficiency, age of acquisition and exposure of participant's to L2 (obtained from Leap-Questionnaire) a linear regression analysis was carried out. Thus, naming latencies obtained by participants at the end of the training were entered in this analysis as dependent variable, whereas the level of proficiency in English (in reading, speaking and listening), the level of exposure in English (interaction with friends, interaction with family, reading exposure, TV/media exposure, radio/music exposure and self-study) and the age of English acquisition were considered as predictors. Another linear regression analysis was separately carried out for the ambiguous stimuli; in this case, the number of utterances that participants pronounced for these stimuli in English was entered as dependent variable, and the same predictors as in the previous analysis were considered. In both cases, a separated regression analysis was run for each predictor. Analyses were implemented in R software and those trials with incorrect responses were excluded.

Results obtained revealed that naming latencies obtained for English and ambiguous stimuli were significantly explained by both the level of proficiency and exposure in English, particularly by reading proficiency and the exposure to English through reading, with faster naming latencies when proficiency and exposure were higher. Thus, final naming latencies obtained for English stimuli, thus presented in Roman script (considering both novel and familiar words), were significantly explained by the level of general English proficiency (*estimate*=-1.35, *Adjusted* R^2=.06, F(1,98)=7.33, p=.0079), namely, the higher the proficiency of the participant in English, the lower the naming latencies obtained at the end of the training for these stimuli. In particular, the proficiency in reading (*estimate*=-15.095, *Adjusted* R^2=.086, F(1,98)=10.35, p=.0017) and listening (*estimate*=-15.09, *Adjusted* R^2=.086, F(1,98)=10.35, p=.0017) in English were found as the variables that better explained the final reading outcomes obtained for stimuli presented in Roman script, although the level of proficiency in spoken English also contributed to explain the results of the training (*estimate*=-9.38, *Adjusted* R^2=.035, F(1,98)=4.69, p=.032). Furthermore, the naming latencies obtained for novel English words were also explained by general English proficiency (*estimate*=-1.85, *Adjusted* R^2=.10, F(1,48)=6.62, p=.013), and particularly, by the level of proficiency in reading (*estimate*=-20.47, *Adjusted* R^2=.14, F(1,48)=9.25, p=.003) and in listening (*estimate*=-20.47, *Adjusted* R^2=.14, F(1,48)=9.25, p=.003), as well as in spoken domain (*estimate*=-14.42, *Adjusted* R^2=.08, F(1,48)=5.28, p=.026). On the other hand, the exposure to English language also resulted significantly related to the naming latencies obtained for Roman, novel and familiar stimuli (*estimate*=-16.28, *Adjusted* R^2=.057, F(1,98)=6.98, p=.009), particularly in regards to English reading exposure (*estimate*=-11.18, *Adjusted* R^2=.051, F(1,98)=6.36, p=.013), as well as social exposure through family (*estimate*=-11.40, *Adjusted* R^2=.038, F(1,98)=5.016, p=.027) and friends (*estimate*=-9.38, *Adjusted* R^2=.035, F(1,98)=4.89, p=.032). The naming latencies obtained for novel words in Roman script were also significantly explain by the exposure to English (*estimate*=-19.65, *Adjusted* R^2=.07, F(1,48)=4.69, p=.035), particularly by the exposure through reading (*estimate*=-16.91, *Adjusted* R^2=.11, F(1,48)=7.053, p=.01) as well as from friends (*estimate*=-14.42, *Adjusted* R^2=.08, F(1,48)=5.27, p=.026). Moreover, the exposure to English language also contribute to faster naming latencies for ambiguous stimuli in general (*estimate*=-21.90, *Adjusted* R^2=.033, F(1,98)=4.42, p=.037) as well as for ambiguous words in particular (*estimate*=-22.74, *Adjusted* R^2=.06, F(1,48)=4.13, p=.047).

Finally, the number of ambiguous stimuli read in English was found significantly explained by the level of proficiency in English (both in reading, *estimate*= 1.88, *Adjusted* R^2= 0.032, F(1,98)=4.33, p=.039 and listening, *estimate*= 1.88, *Adjusted* R^2= 0.032, F(1,98)=4.33, p=.039) and by the exposure of reading in English (*estimate*= 1.84, *Adjusted* R^2= 0.037, F(1,98)=4.80, p=.030), meaning that the higher the proficiency and exposure in English, the high the number of ambiguous stimuli were read in English than in Russian.

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Appendix

1. Stimuli used in the study (reading aloud task at the training phase and recognition and lexical decision tasks at post-training phase), displayed in the handwritten font used.

Cyrillic Script		Roman Script		Ambiguous Script	
Familiar Words	Novel Words	Familiar Words	Novel Words	Familiar Words	Novel Words
шаг	шаз	kid	kof	gap	gex
шок	шой	law	leq	pot	pex
лак	лец	vet	vaz	cop	cuk
зал	зеж	jam	jod	nap	nem

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