

Native Language Effects on Spelling in English as a Foreign Language: A Time-Course Analysis

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Abstract

The study explores first language (L1) influences on the mechanisms of spelling in English as a foreign language (EFL). We hypothesized that the transparency of L1 orthography influences (a) the amount of hesitation associated with spelling irregular English words, and (b) the size of units EFL spellers operate. Participants were adult speakers of three languages differing by the degree of transparency, Danish, Russian, and Italian ($n = 60$), and a group of English native speakers ($n = 20$). We analyzed keystroke logs from typed spellings of 30 English words. The amount of hesitation (number of corrections and number of long within-word pauses), was equal across all participants groups, thus disconfirming our first hypothesis. Inter-key intervals between onsets and rhymes were longer than within-rhyme intervals, but only in Danes and native English speakers, and not in Russians and Italians. We discuss how the characteristics of the L1 may explain the observed cross-linguistic differences.

Résumé

L'étude explore l'influence de la langue maternelle sur les mécanismes de l'écriture en anglais langue étrangère. Nous avons supposé que la transparence orthographique de la langue maternelle influencerait (a) le degré d'hésitation associé à l'écriture des mots anglais irréguliers et (b) les unités orthographiques que les apprenants de l'anglais langue étrangère utilisent en écrivant. Les participants (apprenants de l'anglais [$n = 60$] danois, russes et italiens, et un groupe anglophone [$n = 20$]) ont épilé 30 mots anglais irréguliers à l'ordinateur; les frappes de touche ont été enregistrées. Le degré d'hésitation (le nombre de corrections et le nombre de pauses longues) était uniforme dans tous les quatre groupes, ce qui infirme la première hypothèse. Les intervalles entre attaques et rimes étaient plus longs que les intervalles entre noyaux et codas, mais seulement chez les Danois et les Anglophones, et pas chez les Russes et les Italiens. Nous discutons comment les caractéristiques de la langue maternelle peuvent expliquer les résultats.

Introduction

A growing number of studies reveal that spelling is a complex cognitive phenomenon relying on sophisticated linguistic knowledge (Caravolas, Hulme, & Snowling, 2001; Fischer, Shankweiler, & Liberman, 1985; Pollo, Treiman, & Kessler, 2007). While cross-linguistic studies of spelling are still relatively scarce, an intriguing pattern of evidence has emerged suggesting that the way people learn to spell is in part shaped by the characteristics of their native language and the writing system (orthography) it uses.

The most well-known cross-linguistic differences in the mechanisms of literacy acquisition are those between alphabetic and non-alphabetic languages. While in alphabetic literacy, phonological skills (the ability to manipulate individual syllables, rhymes and in particular phonemes) play a major role (Allyn & Burt, 1998; Caravolas et al., 2001; Landerl & Wimmer, 2008; Lundberg, Frost, & Petersen, 1988; Muller & Brady, 2001), in non-alphabetic writing systems, of which Chinese appears to be the most well-studied case, the link between phonological skills and literacy is less uncontroversial (Chen & Lin, 2008; Hanley, 2005). But even within the family of alphabetic orthographies, the cognitive skills involved in literacy are not identical across different languages. It has been shown that learning to read and write is easier (and faster) in transparent orthographies, i.e. orthographies where correspondences between letters and sounds are consistent, as in Italian or Finnish, than in opaque orthographies, where these correspondences are inconsistent, as in English or Danish (Caravolas, 2004; Caravolas & Bruck, 1993; Juul & Sigurdsson, 2005; Wimmer & Landerl, 1997; Ziegler & Goswami, 2006). Literacy experts suggest that the reason why opaque orthographies are more difficult to learn is that users of opaque orthographies need to know more than users of transparent orthographies in order to achieve reading and spelling proficiency. Indeed, because sound-spelling correspondences are inconsistent, learning basic phoneme-grapheme conversion rules, which can often be sufficient for reading and writing in a transparent orthography, is far from being sufficient in opaque orthographies; therefore learners of the latter have to develop additional strategies. In opaque orthographies, spelling-sound correspondences are more consistent in larger-than-phoneme units than they are at the phoneme level (e.g., Kessler & Treiman, 2001). Based on this finding, Ziegler and Goswami (2005, 2006) have proposed that readers and spellers of opaque orthographies need to memorize correspondences between sounds and spelling not only for individual phonemes, but also for units of larger sizes, such as rhymes or even whole words. The idea that whole word spelling and reading strategies play a more prominent role for users of opaque orthographies has also been proposed by Katz and Frost (1992), the authors of the *orthographic depth hypothesis*.

The empirical evidence supporting the idea that learners of opaque orthographies rely on units of multiple sizes comes mainly from work on reading. Goswami and colleagues (Goswami, Ziegler, Dalton & Schneider, 2001, 2003) showed that in an opaque orthography (English) non-word reading is influenced by orthographic patterns involving units of both phoneme-size and larger sizes, while for transparent orthography readers (German), only the phoneme level plays a role. Much less is known about spelling unit sizes across languages. Studies of typed spelling have identified syllable as a spelling unit in both opaque orthographies, such as English and French (Kreiner, Price, & Gross, 2008; Zesiger, Orliaguet, Boë, & Mounoud, 1994), and a transparent orthography, Finnish

(Service & Turpeinen, 2001). Further, a few studies have shown that in opaque orthographies, such as English and Danish, spellers are able to consider phonology-orthography correspondences not only at the phoneme level, but also at the level of the rhyme (Juil, 2005; Treiman & Kessler, 2006; Treiman, Kessler, & Bick, 2002). However, whether orthographic transparency and orthographic rules influence the salience of rhymes as spelling units remains uncertain, but seems a conceivable possibility.

In sum, cross-linguistic literature suggests that characteristics of alphabetic orthographies such as orthographic transparency impact both the rate of literacy acquisition and cognitive strategies of reading and spelling in one's native language. Much less is known about whether and how these orthographic characteristics of an individual's first language (L1) impact the mechanisms of second language (L2) literacy, when an L2 is learned.

A previous study of ours (Dich, 2012) aimed to shed more light on these questions and to investigate how the transparency of native language orthography influences cognitive mechanisms of spelling in the L2. One of the hypotheses that the study tested was that learners of English as a foreign language (EFL) whose L1 orthography is opaque would be better at spelling irregular English words (i.e. words whose spelling does not follow any rules and has to be memorized as a whole) than those learners whose L1 uses a transparent orthography. This hypothesis was based on the conjecture that the former spellers would be helped by the better developed whole-word memorization strategies, which are necessary in their native language and which they will have transferred to the L2. A similar hypothesis had been earlier put forward by Figueredo (2006).

The study tested this hypothesis by surveying adult English learners who were native speakers of Danish, Italian, and Russian, as well as a control group of native English speakers. Danish and Italian are close to the opposite ends of the orthographic transparency continuum: while Danish orthography is one of the most opaque alphabetic orthographies, Italian has almost perfect one-to-one letter-sound correspondences. Russian is also an opaque orthography in the sound-to-spelling direction, although phoneme-grapheme correspondences are more predictable than in Danish. The results of the study did not confirm the initial hypothesis: the accuracy of irregular word spelling was not significantly predicted by the L1 in EFL learners. However, even though there were no differences in the overall accuracy of irregular word spelling, other results of the same study suggested that the cognitive mechanisms of English spelling were different across the four groups: the spelling strategies participants used when spelling in English were found to be different across groups, with the most "popular" strategy for each group being the one that is the most useful in their native language.

The finding of different strategies, combined with the absence of observable differences in spelling accuracy, suggests that we might get a better understanding of the data, including the influences of native language on L2 spelling, if we look at spelling as a dynamic process tracking its course, rather than simply assessing the accuracy of spelling results.

The idea that such a dynamic approach to writing might prove instrumental in understanding the complex cognitive mechanisms of spelling is of course not new. Such an approach has been advocated since the early 1980s (e.g., Matsushashi, 1982). The advent of modern technology has allowed researchers to analyze the course of typed writing by logging keystrokes, and a number of methods for doing that have already been developed

and used to answer various questions about how people write (e.g., Sullivan & Lindgren, 2006).

This is also the approach that we have undertaken in the project reported here, which is a secondary analysis of the irregular word spelling data from the study discussed above. The way participants' spellings were recorded in the irregular word spelling task, explained in further detail in the Method section, makes it possible not only to look at the final spelling results, but also to track how participants arrived at the correct results, following each of the key strokes they made and analyzing inter-key time intervals. This data gives us an opportunity to start exploring a number of questions related to the influence of native language orthography on L2 spelling. In particular, two questions will be of interest in the present report.

The first question is whether characteristics of native language orthography, namely orthographic transparency, influence the amount of hesitation spellers have before they arrive at the final correct spelling. The hypothesis here is that even when spellers' L1 is not predictive of the accuracy of irregular word spelling in English (L2), it may be predictive of the amount of effort it takes to spell English words correctly. Thus, spellers whose native language has an opaque orthography, giving them more practice in memorizing irregularly spelled words, may find it easier to memorize irregular words in English and experience less hesitation when spelling them than spellers whose L1 uses a transparent orthography.

The second question explored in the study concerns the universality of spelling units. More specifically, we are interested whether spellers' native language orthography has an effect on the size of sub-syllabic spelling units they use when they spell in EFL. As mentioned above, previous research in reading found that orthographic transparency determines the size of units readers operate in their native language: whereas transparent orthography users rely only on phoneme-sized units, opaque orthography users rely on both phoneme-size and larger size units, in particular rhymes. Similarly, English native spellers have been found sensitive to spelling patterns at the level of phoneme as well as at the level of rhyme (Treiman & Kessler, 2006). Consistent with these results, Kreiner and colleagues (Kreiner et al., 2008), who investigated linguistic correlates of pauses in typed English spellings, found that syllable, onset-rhyme and phoneme boundaries predicted pauses in typing English words. However, because the authors only tested native speakers, we do not know if the same mechanisms would apply to spellers for whom English is a foreign language. We hypothesized that large sub-syllabic units such as rhymes will be salient only for spellers whose L1 orthography is opaque and has spelling regularities at the rhyme level.

To explore these two questions, we undertook a secondary analysis of keystroke data collected in our previous study, which investigated English spelling skills of English learners from different language backgrounds.

Method

Participants

Participants were undergraduate and graduate students recruited from Danish, Italian, Russian, and American universities. The original pool of participants, described in Dich (2012), consisted of 100 Danish speakers, 98 Italian speakers, 104 Russian speakers and 95 English native speakers. All of the participants had met the following selection

criteria: (a) participants' native language had to be the first language they learned to speak and read in; (b) participants' native language had to be the one they are the most fluent in, both in speaking and in writing; (c) participants' native language had to be the dominant language of their everyday communication; (d) participants' native language had to be the native language of their both parents (or caregivers); (e) participants must have lived in the country where their native language is spoken for the most part of their life; (f) at the moment of testing, participants had to be living in the country where their native language is spoken; and (g) for Danish, Italian, and Russian speakers, English had to be a foreign language. According to EFL participants' self-reports, the top three factors contributing to their learning English were school and/or language courses, reading in English, and watching movies, TV and/or listening to the radio in English.

The original study also collected information on participants' English proficiency, their native language proficiency and demographic data. For the subset of 80 participants who were selected for the present analysis (see below for the explanation of the design and data selection) demographic and linguistic proficiency characteristics are given in Appendix A.

Task and procedure

The original study had a form of a web-based survey, in which subjects participated remotely from their home computers. The task discussed here consisted of spelling 30 commonly misspelled irregular English words. The following criteria were used for creating the list of words for Task 1: (a) breaking the words up into morphemes or using analogies with words that sound similar would not help to deduce the correct spelling of the words; (b) the words were not direct borrowings from Danish, Italian (Latin), or Russian; and (c) the words had familiarity ratings higher than 6.5 on the 7-point scale (the familiarity estimates were taken from Nusbaum, Pisoni, & Davis, 1984). The words were selected from four online databases of commonly misspelled English words: About.com (n.d.), Ballard (n.d.), LoveToKnow, Corp. (n.d.), and WWW.ESLDesk.com (n.d.). Examples of words for Task 1: *Wednesday*, *neighbor*, *pigeon*. The list of words can be found in Appendix B.

The list of words was recorded in an audio file, with every word repeated twice by two different native English speakers (general American pronunciation), with a 3 s interval. Participants were instructed to type the words as they listened to the recording in the space provided on the screen. After the list of words had been spoken to the end, participants were asked to revise their answers and press *submit*.

The program controlling the study recorded participants' answers in two ways. As participants started to type their answers, each keystroke was recorded, which allows us to track participants' corrections. In addition, for each keystroke, a time stamp in milliseconds was recorded, making it possible to measure latencies for each symbol. The time was recorded locally, on the users' home computers, and then transmitted to the server. In addition, the final revised version of participants' answers was recorded as regular text. The latter was used for accuracy analysis.

Data selection

When analyzing accuracy, both British and American spellings were scored as correct. For the purposes of the present study, 20 best spellers were selected from each language group. In the resulting groups, each participant spelled at least 27 out of 30 words correctly. The subset of best spellers was created because we were primarily interested in investigating the mechanisms underlying correct spellings: the amount of hesitation before the correct spelling is produced, and the correspondence between spelling timing patterns and linguistic units in fluent spelling. The four groups were matched on the overall number of correctly spelled words. The words that were not spelled correctly were removed from further analyses (Appendix B). There were 559 or 560 correctly spelled words per group, making it the total of 2238 words available for the analysis.

Analyses and Results

Amount of Hesitation

Keystroke analysis.

The keystroke sequence was further analyzed for each of the 2238 words in order to determine whether the word was spelled correctly at the first attempt or if there were corrections. Some corrections were made as the word was being typed, while some were made later, after the whole word was typed or during the revisions following the dictation. There were on average 4.2 ($SD = 1.9$) corrected words in the Danish group, 4.0 ($SD = 2.8$) in the Italian group, 4.6 ($SD = 2.7$) in the Russian group, and 4.3 ($SD = 2.7$) in the English native speaker group. The between-group differences in the number of corrected words were not significant, $F(3, 76) = .2, p = .9$. The number of corrections is one indicator of how much hesitation spellers had before settling on the correct spelling. In our group of highly proficient spellers, this indicator did not depend on their native language.

The corrected words were excluded from the subsequent analysis of latencies. The exact number of corrections per word per group is given in Appendix B.

Analysis of latencies.

In addition to calculating the number of corrections, another way to test the amount of hesitation spellers had before arriving at the correct spelling is to look at the time course of spelling and calculate the number of inter-key intervals that are significantly longer than the participant's average. Before this can be done, a few steps in data processing and analysis need to be taken.

The time intervals between each non-word-initial keystroke and the preceding stroke, i.e. the number of milliseconds it took the speller to type each following symbol, were analyzed. The average typing speed was 203 ms per symbol ($SD = 175$) for Danish, 222 ms ($SD = 184$) for Italians, 276 ms ($SD = 234$) for Russians, and 166 ms ($SD = 142$) for English native speakers.

The distribution of values was not normal, but right-skewed with a long tail of high-value outliers. Therefore, to make the distribution more symmetric and the use of ANOVA and regression analyses possible, the data were log-transformed. The ANOVA analysis of

the averaged by subject log-transformed data showed significant between-group differences in the average typing speed, with the Russians being the slowest and the English native speakers the fastest, $F(3, 76) = 14.9, p < .0001$. Pairwise comparisons (Tukey's test) showed that at $\alpha \leq .05$ Russians were significantly slower than each of the other three groups and Americans were faster than all non-native speaker groups. The difference between Italians and Danes was not significant. These results are likely to be explained by the fact that the native speakers have the largest amount of practice typing English words, while Russians have the least amount of practice using Roman letters since their own native language uses the Cyrillic alphabet.

In order to adjust for differences in typing speed between participants, the data were standardized by subtracting the participant's average and dividing the result by the participant's standard deviation. Thus, the resulting values indicated how long it took to type each letter relative to the participant's typing speed instead of indicating the absolute time interval. For instance, the score of 2 would mean that the amount of time it took the participants to type the letter was two standard deviations over the participant's average number of milliseconds per symbol. The standardized value ranges were: -6.1 to 4.5 for Danes, -4.2 to 4.5 for Italians, -4 to 4.6 for Russian, and -6.4 to 4.6 for English native speakers.

These standardized inter-key time intervals were further used to do the second test of the amount of hesitation and calculate the number of intervals longer than two standard deviations above the participant's average, comparing this number across the four groups. There were 72 such long intervals in the native speaker group, 91 in the Danish group, 95 in the Italian group, and 77 in the Russian group. This between-group difference was not significant, $\chi^2(3) = 3.6, p = .3$. However, a correlation was found between the number of corrections per word and the number of long pauses per word, $r = .4, p = .03$. Words that triggered many corrections also triggered many long pauses.

Spelling Unit Size

The next step of the analysis was to examine whether there were patterns in typing speed corresponding to sub-lexical linguistic units. The first unit to be explored was the syllable. From the dataset described above (z-scores obtained from log-transformed time intervals) a subset of points was selected corresponding to the syllabic boundaries in the pronunciation of the words. The selection was made based on the phonetic transcription given in Merriam-Webster Dictionary (n.d.) and MRC Psycholinguistic Database (n.d.). Sometimes it was not clear what the correspondence of the syllable boundary in the spelling of the word was (e.g., *fo-reign* vs. *for-eign*; *tomo-rrow* vs. *tomor-row*). The syllabic boundaries with unclear spelling correspondences were not included in the analysis. The total number of considered syllabic boundaries was 27 and those are marked in Appendix B.

The global average inter-syllable interval was 0.5 ($SD = .22$), which was equivalent to approximately 311 ms in the raw data and which was significantly higher than the average between-letter interval within syllables, approximately 216 ms, $t(79) = 20.8, p < .0001$. No significant differences in the average inter-syllable interval were observed between the four language groups, $F(3, 76) = .7, p = .6$. One explanation for this result could simply be that certain letters that in this word set, more likely to occur at the beginning of the syllable than within the syllable, were also the ones that take longer to

type in general (e.g., because they are rare). To account for this possibility, the average typing speed was calculated for each letter and then treated as a covariate in a comparison of between-syllable intervals with within-syllable intervals. For this analysis the subset of data was created consisting only of letters that occurred both at the beginning of the syllable and within syllable. The position of letter was still a significant factor: it took longer to type letters in the beginning of the new syllable than it took to type the same letters when they were not at a syllable onset, $F(1, 114.3) = 159, p < .0001$. This calculation was performed using a Linear Mixed Effect (LME) model (e.g., Pinheiro & Bates, 2000), where the log-transformed standardized intervals were the response, the position in word and average letter typing speed were fixed effects and Subject and Subject x Position were random effects. The difference was equal to .45, equivalent of approximately 302 ms in the raw data.

This result shows that in all four groups of spellers, phonological syllables of English words have correlates in typing speed and can be considered one type of unit that spellers operate when typing in English, independent of their native language. Sub-syllabic units, namely onsets and rhymes were studied next. Just like for inter-syllable intervals, we used standardized log-transformed data for this analysis. A subset of data was created corresponding to the intervals between onsets and rhymes (e.g., *gh-ost*, *ch-oice*) and between vowels and codas within the rhyme (e.g., *trou-ble*, *spee-ch*). Cases where it was not clear where the correspondence of these sub-syllabic units in the word's orthography was (e.g., *hei-ght* vs. *heigh-t*) were excluded. Fifty-three onset-rhyme intervals and 30 vowel-coda intervals were analyzed. Those are marked in Appendix B.

The average within-rhyme interval (i.e., the interval between the vowel and the coda) across the four language groups was .06 ($SD = .24$), which is equivalent to approximately 226 ms. The average onset-rhyme interval was -.11 ($SD = .19$), equivalent to approximately 195 ms, i.e., circa 31 ms shorter. Controlling for the average letter typing speed, however, the adjusted mean onset-rhyme interval was .08 – approximately 16 ms – longer than the adjusted mean within-rhyme interval and in the whole sample of participants, this difference was only marginally significant, $F(1, 171.1) = 3.0; p = .09$. But the important finding was that this difference was not uniform across the four language groups, $F(3, 76) = 5.7, p = .001$. Specifically, adjusted for average letter typing speed, onset-rhyme intervals were *longer* than within-rhyme intervals for English native speakers and for Danish speakers. The difference was .24 (approximately 46 ms) for English speakers and .26 (approximately 49 ms) for Danish speakers and was significant for both groups – $F(1, 54.5) = 9.7, p = .003$ and $F(1, 50.7) = 8.0, p = .007$ respectively. For Russians and Italians, however, onset-rhyme intervals were on average *shorter*, although not significantly, than within-rhyme intervals. The difference was .11 or approximately 20 ms for Russians, $F(1, 37.4) = .9, p = .4$, and .03 or approximately 6 ms for Italians, $F(1, 87.9) = .2, p = .7$.

Regression analyses revealed that native language covariates, i.e., characteristics measured in the study on which the four groups were not matched (Appendix A), could not account for why onset-rhyme intervals were longer than within-rhyme intervals in the English and Danish speaking groups, but not in the Russian and Italian speaking groups. Controlling for age, interest in language, number of foreign languages ever learned, age of learning to read and write in the native language, and native language spelling skills, participants' native language remained a significant predictor of the difference between onset-rhyme intervals and within-rhyme intervals, $F(3, 68) = 6.7, p = .0005$. It also

remained significant when only EFL participants were considered and age of English acquisition was added as a covariate to the regression model, $F(2, 49) = 8.9, p = .0005$.

Discussion

The present paper analyzed keystroke and latency data recorded from a spelling task asking participants, native speakers of four different languages, to spell irregular English words. The goal of the study was to gain more insight about spelling as a process by tracking its time course and to investigate whether participants' native language influenced the mechanisms of spelling in English.

Specifically, we pursued two questions: whether the amount of hesitation participants exhibited before they settled on the correct spelling depended on participants' native language and whether the linguistic units participants used in spelling in English depended on their native language.

The participants from the four L1 groups were matched on their English spelling proficiency: they all were selected from a larger pool of subjects participating in the irregular word spelling task and were the top spellers in their language groups, correctly spelling no less than 27 out of 30 words. Only correct spellings were analyzed.

To answer the first question, we used two measures: (a) the number of corrections participants made, either as participants typed or during the revisions before submitting their final answers and (b) the number of long pauses in the process of typing the word, which were defined as being two or more standard deviations above an individual's average inter-key interval. While these two measures were correlated with each other, no between-group differences were found on either measure, thus refuting our original hypothesis that L1 orthographic transparency would predict the amount of effort it takes to spell English irregular words correctly¹. This means that the amount of difficulty that participants experienced typing the commonly misspelled English words was the same, no matter how much experience with irregular word spelling and whole word memorization they had in their native language.

In order to explore the second research question, we first looked at syllable and rhyme units in order to see whether the inter-key intervals within these units were significantly shorter than the time intervals between units. We found that the intervals between syllables were longer than the intervals within syllables. This finding still held when we accounted for the fact that some letters take longer to type due to, for instance, their low frequency or position on the keyboard. Moreover, we found that the correlates to syllables in typing time course were universal for all four language groups. This finding is in agreement with previous literature that investigated spelling by typing, which has identified syllables as spelling units in English (Kreiner et al., 2008), as well as in French (Zesiger et al., 1994) and Finnish (Service & Turpeinen, 2001). Our results contribute to the previous literature by showing that the syllables appear to be English spelling units not only in native English speakers but also in learners of EFL.

We further compared within-rhyme intervals, i.e., the intervals between vowel and coda, with onset-rhyme intervals, again taking into account that some letters take longer to type than others. Consistent with our prediction, participants' native language predicted whether rhyme emerged as a sub-syllabic spelling unit. In Danish speakers and native English speakers, the within-rhyme intervals were significantly shorter than those between

onset and rhyme, while in Russians and Italians they were not. Thus, the data confirmed the hypothesis that units of spelling would be different across English learner groups.

Because we used standardized data in our calculation, the between-group differences in typing speed cannot explain the present results. Nor could they be explained by native language covariates: controlling for variables correlated with native language (participants' demographic characteristics and language proficiency variables) did not change the significance of the found cross-linguistic differences. We believe that the explanation for cross-linguistic differences in spelling units can be found in the characteristics of participants' native languages, with the orthography being the main candidate to account for our findings.

Research in English spelling orthography has shown that the unpredictable phoneme-grapheme correspondences become more predictable if units larger than phonemes are considered. More specifically, in English, phonological coda often conditions the spelling of the vowel, e.g., /o/ is most likely to be spelled as <oa> before a two-consonant rhyme, as in *toast*, /e/ is most often spelled as <ai> before /n/, as in *rain* (Kessler & Treiman, 2001). Spellers are sensitive to such orthographic patterns (Perry & Ziegler, 2004; Treiman & Kessler, 2006; Treiman et al., 2002), suggesting that for English spellers a rhyme represents an operational unit. Similar orthographic patterns also exist in Danish, and Danish spellers have been found sensitive to such patterns (Juil, 2005). At the same time, neither in Italian, nor in Russian, is spelling of the vowel determined by the coda context. The only contextual rules that do exist in the two languages connect the spelling of the vowel and the spelling of the preceding consonant. Thus, it seems plausible that for English and Danish speakers rhyme is a more salient unit of spelling than for Russians and Italians, which is reflected in how spellers group symbols when they type, not only in their native language, but also in their L2 – English.

At the same time, an alternative non-orthographic explanation is conceivable. In cross-linguistic studies in phonology an idea has been entertained for some time that the rhyme is not a universal phonological unit and that while in some languages, such as English, the association between vowel and coda is stronger than that between onset and vowel, in other languages, the opposite is the case (Lee & Goldrick, 2008; Yoon & Derwing 1994, 2001). It has been proposed that the strength of association between parts of the syllable depends on distributional properties of consonants and vowels in a language (Lee & Goldrick, 2008). While work showing that within-rhyme phonological associations in Italian and Russian are not as strong as those in Danish or English is yet to appear, one should acknowledge that such results could potentially provide an alternative explanation to our findings.

In conclusion, to the best of our knowledge, our paper is the first to provide evidence suggestive of cross-linguistic differences in the size of units that spellers operate when they spell in English. We believe that these differences can be at least in part explained by the characteristics of spellers' native language orthography, more specifically orthographic transparency and contextual spelling constraints. We have proposed that these cross-linguistic differences result from spellers' transfer of their L1 spelling strategies: i.e., native language characteristics influence the ways spellers parse words when they type in L1, and when they learn to spell in English as an L2, they group the symbols the same way they would do in their native language. Future cross-linguistic research aimed at investigating spelling units across L1s using orthographies of varying transparency is needed to corroborate our findings.

Notes

¹ As pointed out by an anonymous reviewer, when analyzing the time-course of spelling to determine the amount of hesitation, we do not take into consideration the time it took the participant to start typing after s/he recognized the word, which might have been spent pre-planning the spelling. In our study, it was not possible to estimate this time primarily because each word was repeated twice on the recording and it is impossible to find out whether a participant did not start typing after hearing the word once because s/he was thinking about the spelling or because s/he did not recognize the word. By not accounting for the time it took to initiate spelling we may admittedly be losing some information on the amount of hesitation. However, given that there were no cross-linguistic differences in the other two measures of hesitation, it seems unlikely that we would find cross-linguistic differences in the time spent pre-planning spelling.

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Appendix A

Table 1

Demographic and language proficiency characteristics of the participants

		DA	IT	RU	EN
Average Age (Range)^a		23 (20-30)	25 (20-35)	22 (18-30)	20 (18-21)
Gender ^b	Male	11	8	8	7
	Female	9	12	12	13
Interest in Language^c	Not Interested	0	0	0	3
	Somewhat Interested	8	1	5	10
	Very Interested	12	19	15	7
Avg. #FL (SD)^d		3.4 (1.1)	3.0 (1.1)	2.9 (1.4)	1.1 (.6)
Average Age NL Literacy^e (SD)		6 (1.5)	5 (1.0)	3 (1.1)	3 (.8)
NL Spelling^f	Good or lower	2	1	2	4
	Very good	1	1	5	10
	Excellent	6	9	8	4
	Perfect	11	9	5	2
Age EN (SD)^g		9 (1.4)	9 (3.3)	7 (2.2)	N/A
EN Speaking^h		4	4	3	N/A
EN Understanding^h		4	4	3	N/A
EN Reading ^h		4	4	4	N/A

Note. Variables where significant between-group differences were found are bolded. Pairwise comparisons are provided in table footnotes. Statistical significance is defined by $\alpha = .05$.

^a Differences between the following groups are significant: Italian – English; Danish – English; Italian – Russian.

^b Pairwise differences not significant.

^c Answer to the multiple choice question: “How interested are you in language/linguistics?” The three response options are provided in the table. Differences between the following groups are significant: Russian – English; Italian – English; Danish – Italian.

^d Number of foreign languages ever learned. Each of the EFL groups is significantly different from English speakers. No significant differences between the three EFL groups.

^e Age when started to learn to read or write in the native language. All pairwise differences except the one between English and Russian speakers are significant.

^f Native language spelling proficiency, based on participants' self-report using a 10-point scale from 1 – *very low* to 10 – *perfect*. Because there were very few participants who assessed their spelling to be worse than “good”, the scale was collapsed to four categories. The use of self-reports was based on the finding that individuals' self-reported spelling ability correlates with their actual ability (Schulte-Korne, Deimel, & Remschmidt, 1997). Each of the EFL groups is significantly different from English speakers. No significant differences between the three EFL groups.

^g Age started learning English. Pairwise differences between Russians and the other two EFL groups are significant.

^h English proficiency. Participants were asked to assess their English proficiency on a 10-point scale, from 1 – *very low* to 10 – *perfect*. They assessed their speaking, understanding, and reading skills. Due to the low number of ratings lower than 5, the 10-pt scale was collapsed to a 5-point scale. The use of self-reports for English proficiency assessment was based on the finding by Marian and colleagues (Marian, Blumenfeld, & Kaushanskaya, 2007) that self-reported L2 proficiency correlates with the results of objective assessments. The authors of the study argue that self-reports can be used as the means for language proficiency assessment instead of language tests. Pairwise differences are significant between Italians and Russians for speaking skills and between Danes and Russians for understanding skills.

Appendix B

Table 2

Words used in the study, the number of misspelled words and words which were not spelled correctly at the first attempt

syllabic boundaries	sub-syllabic boundaries	Incorrect				Corrected			
		DA	IT	RU	EN	DA	IT	RU	EN
a-chieve-ment	ach ie/vem e nt	1	0	3	2	3	6	8	5
ack-now-ledg-ment	a ckn owl e dgm e nt	3	5	1	0	5	4	2	6
a-verage	aver a ge	0	0	0	0	3	2	0	1
beau-ti-ful	b eaut if u l	0	0	1	0	4	5	5	7
be-lieve	b el ie ve	0	0	0	0	2	4	0	2
cabbage	c abb a ge	2	0	0	0	4	1	3	0
choice	ch oi ce	0	0	0	0	2	2	2	2
en-viron-ment	e nv ironm e nt	0	1	0	0	3	2	4	4
fore-head	f oreh ea d	0	0	2	2	4	4	3	5
foreign	f oreign	0	0	1	1	2	1	1	2
for-ty	f ort y	5	1	5	4	0	1	1	4
friend	fr ie nd	0	0	0	0	3	1	2	3
ful-fill	f u lf i ll	0	1	0	2	4	2	5	4
ghost	gh o st	0	0	2	0	0	2	1	3
height	h eight	0	2	0	0	5	2	2	1
in-surance	i ns ura nce	2	1	2	1	5	2	5	0
jewel-ry	j ewelr y	1	3	7	8	4	5	5	3
kin-der-gar-ten	k i nd erg art e n	6	10	7	6	2	4	7	4
lei-sure	l eis ure	1	2	0	1	3	1	3	2
neigh-bor	n eighb or	1	0	1	0	2	3	3	1
pi-geon	p ig eo n	5	6	3	3	2	2	2	3
rasp-berry	r a spb err y	4	1	2	5	2	3	1	6
scissors	sc iss ors	0	1	0	3	2	3	2	1
speech	sp ee ch	6	2	1	1	2	4	2	6
sur-geon	s urgeo n	1	4	1	2	1	3	4	1
to-morrow	t om orrow	0	0	0	0	4	2	4	3
trouble	tr ou ble	1	1	0	0	0	2	4	1
un-til	u nt i l	0	0	0	0	4	0	0	3

Wednes-day	W ednesd ay	1	0	0	0	7	3	5	2
Weird	w eird	0	0	1	0	0	3	2	1

Note. Dashes (-), vertical bars (|) and slashes (/) denote (respectively) syllable, onset-rhyme and vowel-coda boundaries included into the analysis of latencies.