Are you reading what I am reading?
The impact of contrasting alphabetic scripts on reading English

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1   Introduction

This study examines the impact of the cross-linguistic similarity of translation equivalents on word recognition by Russian-English bilinguals, who are fluent in languages with two different but partially overlapping writing systems. Current models for bilingual word recognition, like BIA+, hold that all words that are similar to the input letter string are activated and considered for selection, irrespective of the language to which they belong (Dijkstra and Van Heuven, 2002). These activation models are consistent with empirical data for bilinguals with totally different scripts, like Japanese and English (Miwa et al., 2014). Little is known about the bilingual processing of Russian and English, but studies indicate that the partially distinct character of the Russian and English scripts does not prevent co-activation (Jouravlev and Jared, 2014; Marian and Spivey, 2003; Kaushanskaya and Marian, 2007).

Many Russian-English translation equivalents are in part composed of shared letters that can potentially activate both Russian and English word candidates. Often, these letters have ambiguous phonemic mappings across the two languages. The degree of ambiguity is high especially when shapes of block-letters and letters in italics overlap across languages. For instance, a printed Russian letter 'и' does not look like any letter of the English alphabet, but the shape of its handwritten equivalent 'u' perfectly coincides with the English hand-written grapheme. We identified 5 overlapping pairs of printed English block-letters and Russian letters in italics (g, r, m, n, u).

Our study started from the assumption that even when a bilingual reads English words in printed font, letter shapes also activate handwritten Russian letters with similar shapes in a bottom-up way. We focused on the impact of convergence and divergence in Russian and English script coding for cognates and non-cognates. Cognates are translation equivalents with significant cross-linguistic form overlap in phonology and/or orthography (e.g., 'marriage' in English, 'mariage' in French). Cognates are generally processed more quickly by bilinguals than matched control words (for an overview of studies, see Dijkstra, Miwa et al., 2010). However, as far as we know, cognate processing for the Russian-English language pair has not been examined before.

2   Predictions

We are making the following predictions about English word recognition by Russian-English bilinguals:
1. In English word processing, Russian-English bilinguals will activate lexical candidates that are similar to the input word in both Russian and English (language non-selective lexical access).
2. English-Russian cognates will be recognized more quickly than English control words, due to co-activation and convergence (cognate facilitation effect, Dijkstra, Miwa et al., 2010; Lemhöfer and Dijkstra, 2004).
3. Cognates with ambiguous orthography, i.e. shared letters mapping onto different phonemes in the two languages, will be processed more slowly than cognates with mismatching orthography, due to decreased facilitation from the other cognate member.

The following two predictions are more speculative and exploratory in nature.
4. Response times to cognates with transparent orthography, i.e. shared letters mapping onto the same phonemes in the two languages, will be about equal to those for cognates with mismatching orthography, because transparent orthography and shared phonology will lead to increased lexical competition, but, at the same time, the

transparency will lead to increased semantic co-activation of cognates in the two languages.

5. English control words with mismatching orthography will be processed more quickly than words with ambiguous orthography, because less interference from the Russian alphabet is expected in the first case.

3   Method

To test these hypotheses, we first constructed a large database of Russian-English cognates with three, four, five or six letters in length. To our knowledge, no such database is currently available to the community of researchers. Next, 75 English cognates were selected as test words in a lexical decision task. Orthographic coding was performed on English cognate words written in lower-case block letters in Arial font. The resulting items were allocated to three categories: 1) Cognates with Ambiguous Orthography (CAO=Minus condition), composed of letters that have different phonological mappings in English and Russian (e.g. 'guru' might be read as /digi/ if a Russian monolingual was asked to read this string of letters); 2) Cognates with Transparent Orthography (CTO=Positive condition), composed of letters that largely share their orthographic-phonological mappings with letters of the Russian alphabet (e.g. in 'koala' the only mismatch with the Russian alphabet is the grapheme 'l'); 3) Cognates with Mismatching Orthography (CMO=Base condition), composed mostly of letters that do not exist in the Russian alphabet (e.g. 'filter'). The cognate types were matched across conditions (CAO/CTO/CMO) in word length, frequency, and degree of cross-linguistic orthographic overlap between Russian and English alphabets. Three groups of control words were then selected that matched the cognates of each type with respect to these three dimensions. Finally, each cognate and non-cognate was matched with a pseudo-word generated with the help of the Wuggy-software (crr.ugent.be).

Next, 20 Russian-English bilinguals were asked to rate the visual similarity between the English cognates and their Russian translation equivalents. They also rated the semantic similarity of all selected item pairs. Rating results showed that bilinguals mostly considered orthographic congruence (as opposed to incongruence) between the orthography of Russian and English translation equivalents and gave higher ratings to English words that have shared orthography with the Russian alphabet. Ratings also indicated that bilinguals considered not only block-letters but also corresponding handwritten graphemes when rating the visual similarity between words.

In total, 37 Russian-English participants (10 male vs. 27 female; age: 19-60 years) took part in the study. At the moment of testing, all participants were residing in English-speaking countries: 11 participants in Bristol, UK, 21 participants in Sheffield, UK, and 5 participants in New Zealand. After the experiment, all participants rated their proficiency in English on a scale from 1 (the lowest) to 6 (the highest). Average ratings for reading, writing, speaking, and listening varied between 4.4 and 5. Except for two participants, ages of L2 acquisition (AoA) ranged between 6 and 19 years. Length of residence in an English-speaking country varied between 3 months and 21 years (mean = 33 years, SD = 11 years).

Participants performed an English lexical decision task, in which they pressed a "yes" or a "no" button depending on whether a presented word was English or not. They were asked to press a button as quickly and accurately as possible. The items were presented in a pseudo-randomized order to each participant. The experiment was programmed in E-Prime. Reaction times (RTs) and accuracy of responses were measured. Only correct responses to real words were included in the analyses of reaction times.

4   Results

First, all responses faster than 300 ms and slower than 3 s were removed from the data set, because they were not considered as valid measurements. Next, the data from 9 participants were excluded from analysis, because they had a response accuracy below 70%. We removed 5 cognates, 8 control words, and 14 non-words from the items, because these items had an accuracy below 70 % or had extremely slow responses. For the remaining 28 participants, after removing these items, cognate and control word conditions were still matched with respect to length and frequency (as shown by non-significant t-tests). None of the remaining responses were further apart than 2.5 SDs from the participant mean in each condition. The mean RT for non-words was 892 ms. Table 1 presents the mean RTs for words in each cognate and control word condition, as well as their accuracy.

Condition Type	Cognates	Controls	RT difference
Base	661 (82.2) .97	727 (112.7) .95	66
Minus	711 (105.7) .94	734 (106.4) .93	23
Plus	656 (89.01) .97	730 (113.1) .92	74

Table 1. Mean reaction times and accuracies for word categories (standard deviations between parentheses).

The word data were analyzed by means of a repeated-measures Analysis of Variance (ANOVA), using cognate type (3, MO vs. AO vs. TO) and cognate status (2, cognate vs. control) as within-subject factors. This analysis resulted in main effects of Cognate Status (F (1, 27) = 94.11, p<.001), Item Type (F (2, 54) = 9.89, p<.001), and an interaction of Cognate Status with Item Type (F (2, 54) = 10.22, p<.001). Next, we did planned comparisons to test the Cognate Minus (CMO) and Cognate Plus (CTO) conditions against the Cognate Base (CMO) condition. Significant differences were found between the RTs between the Cognate Base condition and the Cognate Minus condition (t(27)=-5.0, p<.001 two-tailed) but not between the Cognate Base and the Cognate Plus condition (t(27)=.60, p=.55). There was a significant difference between the Cognate Base condition and the Control Base condition (t(27)=-6.54, p<.001). Finally, no significant differences arose between the different control conditions (Control Base vs. Control Minus, t(27)=-.67, p=.51; Control Base vs. Control Plus t(27)=-.36, p=.72).

5   Discussion

Russian-English bilinguals performed an English lexical decision task with purely English control words and English-Russian cognates 1) with mismatching orthography or 2) shared orthography with a) transparent or b) ambiguous mappings on phonemes in Russian and English.

Responses to cognates were faster than to English controls (see Table 1). This cognate facilitation effect is in line with prediction 1 that lexical candidates in both Russian and English are activated during Russian-English bilingual word recognition.

It also confirms prediction 2 that language non-selective lexical access takes place in Russian-English word recognition. Because the ef-

fect is also observed in cognates with (partially) mismatching orthography, the cognate effect may in part be ascribed to the phonological and semantic overlap in these cognates. Thus, the orthographic input representation quickly leads to an activation of sublexical and lexical phonological representations (cf. Peeters et al., 2013).

In line with prediction 3, the cognate facilitation effect is modulated by the degree of shared transparent overlap between Russian and English alphabets. Cognates with transparent orthography were processed faster than cognates with ambiguous grapheme to phoneme mappings. This finding can be explained by assuming that Russian words are co-activated with English words to the extent that they match the English letter input, irrespective of whether this matching is in terms of block letters or handwritten visual similarity. In other words, it is purely a bottom-up (signal-driven) effect.
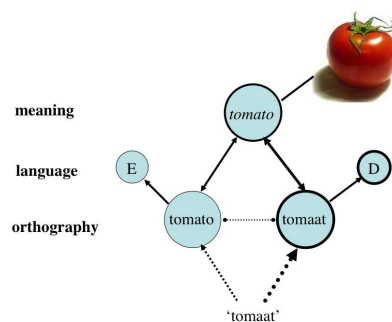

Figure 1. Localist connectionist illustration of cognate representation and processing, adapted from Dijkstra, Miwa et al. (2010).

The finding that cognates with mismatching orthography and shared orthography with transparent grapheme-to-phoneme mappings are responded to about equally fast, is in line with prediction 4, which is based on the representation for cognates that has been proposed by Dijkstra, Miwa et al. (2010). As Figure 1 indicates, both form representations of cognates are assumed to be activated based on the input and they spread activation to convergent semantic representations. The co-activation of form representations results in lexical competition and interference (Dijkstra, Hilberink-Schulpen et al., 2010), whereas the convergence on semantics results in facilitation. As a result, the RT difference between cognates with mismatching orthography and shared transparent orthography may be relatively small, due to a cancelling out of the effects of increased lexical form competition and increased semantic co-activation.

Finally, in contrast to prediction 5, English control words with mismatching orthography were not processed more quickly than control words with ambiguous orthography. Apparently, mismatching orthography in general did not result in any systematic interference on word processing speed. Said differently, the noise introduced by spuriously activated word candidates from Russian with overlapping letters in the other control conditions did not systematically affect the lexical decision to the English target word, although it may have affected the participants' general decision-making strategies in the experiment. In terms of interactive activation models, the increase in noise could be cancelled out by a somewhat higher reliance on semantic codes or global lexical activation (Grainger and Jacobs, 1996) for making the lexical decision.

In all, the obtained patterns of results are in support of interactive activation models for bilingual word recognition, such as the BIA+ model (Dijkstra and Van Heuven, 2002) when the assumption is made that cognates are represented in terms of overlapping but lexically competing form representations and largely shared semantic representations in the two languages (Dijkstra, Miwa et al., 2010), see Figure 1. Even the somewhat counter-intuitive prediction 4 can find a reasonable explanation in terms of such models. Prediction 5 was not confirmed, but the actually obtained result can be interpreted in terms of slightly shifted lexical decision criteria.

This study confirms the presence of language non-selective lexical access in visual word recognition by different script-bilinguals, in line with, e.g., for Korean-English Kim and Davis (2003) and for Japanese-English Hoshino and Kroll (2008), Miwa et al. (2014), and Ando et al. (2015). Moreover, it bridges research on shared scripts and different scripts by considering the partially overlapping Latin and Cyrillic scripts of English and Russian. It is innovative in showing that cross-linguistic effects depend on the degree of overlap in scripts depending on the exact characteristics of the words involved.

The study also provides indirect support for various types of models that assume co-activation of word candidates that are orthographically similar to the input letter string. The set of such candidates is often referred to as the neighbourhood (Grainger and Dijkstra, 1992). Van Heuven et al. (1998) have shown that the number of neighbours within and between languages affects bilingual word recognition. This result has recently been confirmed by Mulder and Dijkstra (under revision). The present study provides confirmation for these models from a completely independent perspective, that of cross-linguistic similarity effects in scripts.

To conclude, we presented evidence in favor of language non-selective lexical access in Russian-English bilinguals, showing an English-Russian cognate facilitation effect, the size of which depended on whether there was overlap in orthography or not, and on whether this overlap was ambiguous or transparent relative to phonology. These effects were shown to be lexical in nature, because mismatching orthography in control target words with translations that are completely different in form did not show any evidence of differential processing.

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