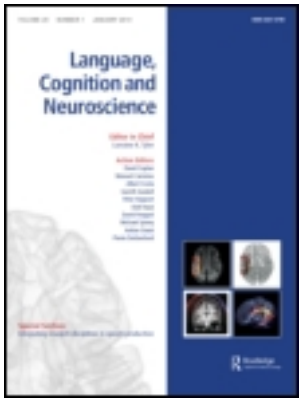

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Stress consistency and stress regularity effects in Russian

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Stress consistency and stress regularity effects in Russian

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This paper presents findings from the analysis of a Russian word corpus and two studies assessing the effects of stress consistency and stress regularity on performance in naming and lexical decision tasks. An examination of the impact of stress in Russian is particularly interesting because, although there is no regular stress pattern overall, first-syllable stress is regular for adjectives. The results demonstrated a processing advantage for regularly stressed adjectives in both tasks. For nouns and verbs, which have no clear regular stress pattern, no differences in the processing of initial- vs. final-stressed words were observed. Further, an advantage in the processing of words with consistent vs. inconsistent spelling-to-stress mappings was detected for all words in naming, but only for irregularly stressed adjectives in lexical decision. These findings provide evidence that readers are sensitive to both stress consistency and stress regularity even when regularity exists only for words of a single grammatical category.

Keywords: lexical stress; stress consistency; stress regularity; visual word recognition; Russian

The majority of theoretical and computational constructs developed in the area of reading research have been concerned with describing the mechanisms involved in the processing of single-syllable words. More recently, the field has seen a shift towards the study of polysyllabic words. The investigation of the mechanisms utilised by readers in the processing of polysyllables raises new scientific questions because, in addition to explaining the mechanisms of grapheme-to-phoneme mapping, one needs to gain an understanding of the principles of lexical stress assignment. Although issues concerning lexical stress have received limited attention in reading research, a number of important questions have been identified. One central issue is determining the mechanism(s) by which stress is assigned. The two basic approaches to modelling the cognitive processes in reading (i.e., the connectionist and the dual-route approaches) have distinct positions on this issue. According to the connectionist view, stress is computed, based on knowledge of statistical probabilities with which various orthographic patterns map onto stress (Arciuli, Monaghan, & Ševa, 2010; Ševa, Monaghan, & Arciuli, 2009). According to the original dual-route view, lexical stress can be retrieved from the lexicon for each word or be computed from non-lexical information using certain rules (Rastle & Coltheart, 2000). In a more recent implementation of the dual-route model (Perry, Ziegler, & Zorzi, 2010), the idea that stress patterns are assigned non-lexically based on rules has been replaced by the claim that non-lexical processing of stress is likely to be grounded in the knowledge of statistical probabilities (i.e., the connectionist principle). Thus, essentially all theoretical approaches suggest that it is necessary to explore the issues of what these stress-assignment rules/statistical probabilities are and how readers utilise them.

There have now been a number of behavioural investigations of the mechanisms of stress assignment (Arciuli & Cupples, 2004, 2006; Colombo, 1992), as well as the development of several computational models attempting to describe how readers assign stress (Perry et al., 2010; Ševa et al., 2009). Unfortunately, the languages in which these issues have been examined have all been from one typological group, that is, languages that possess a very frequent, also known as regular, stress pattern (e.g., English, Spanish, Italian, etc.). Readers of such languages may have a strong bias towards assigning the more frequent stress pattern as a default. This bias may then mask the impact of other factors that also play a role in the process of stress assignment.

The present research is an attempt to address this concern by examining the mechanisms of lexical stress assignment in Russian, a language in which there appears to be no overall regular stress pattern. In addition, as the present Study 1 will document, in Russian there is a regular stress pattern for one grammatical category, adjectives, which are typically stressed on the first syllable. Hence, the present research

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can simultaneously evaluate the extent to which stress regularity plays a role in assigning stress, by considering stress assignment for adjectives, as well as the impact of stress consistency in the absence of a regular stress pattern.

Lexical stress in Russian

As just noted, although Russian is a language without an obvious regular stress pattern, at the same time, there appears to be a certain amount of regularity if we consider the word's grammatical category. Specifically, Russian adjectives seem to be much more likely to have first-syllable stress. In contrast, verbs may be slightly more prone to be second-syllable stressed, whereas nouns do not appear to have a more frequent stress pattern.

Beyond these regularities, what also seems to be true is that the assignment of lexical stress in Russian is not a simple task as stress is neither explicitly marked in the orthography, nor does it conform to any clear implicit rules. Although there are a number of inflectional and derivational morphemes that provide readers with stress position information (e.g., the suffix 'изм' is always stressed as in *фашИзм* ('fascism'), *афорИзм* ('aphorism'), and эго*И*зм ('egoism')), the majority of Russian words are composed of morphemes that are stress-ambiguous (for a review see, Coats, 1976; Lagerberg, 1999). Therefore, even morphological information has limited usefulness in terms of helping readers accurately assign stress.

Due to the complexity of the stress-assignment process for Russian speakers, a widely accepted view has been that a Russian word's stress is assigned only following the retrieval of accurate stress information from the word's lexical representation (Gouskova, 2010; Lukyanchenko, Idsardi, & Jiang, 2011). One goal of the present research is to evaluate this notion by investigating the possibility that native readers of Russian actually do use non-lexical information to assign stress. The nature of two potential cues to stress, specifically, the overall regularity of a particular stress pattern, which may implicate the use of a rule-based mechanism, and the consistency of spelling-to-stress mappings, which may implicate the use of the knowledge of probabilistic statistical associations between orthography and stress patterns, are discussed below.

Stress regularity

As alluded to above, it has been suggested that readers of languages with a regular stress pattern possess implicit knowledge about the frequency of that pattern that causes them to have a strong bias to apply the pattern (Colombo, 1992; Monsell, Doyle, & Haggard, 1989). Indeed, a performance advantage for regularly stressed words over words with irregular stress has been reported in English word naming (Monsell et al., 1989) and in Italian naming and lexical decision tasks (Colombo, 1992), with the effect being stronger for words of low frequency. Finally, some support for a processing advantage of regularly over irregularly stressed words is provided by patient data. Deep dyslexic aphasic patients were reported to be more accurate in reading words with more frequent stress patterns in English (Black & Byng, 1986) and in Italian (Laganaro, Vacheresse, & Frauenfelder, 2002).

Not all results have been supportive of the hypothesis that a regular stress is assigned by default, however. Specifically, there has been no evidence of a stress regularity effect in a number of other studies (in English, Rastle & Coltheart, 2000; in Italian, Sulpizio, Arduino, Paizi, & Burani, 2013; Sulpizio, Job, & Burani, 2012; and in Spanish, Gutierrez-Palma & Palma-Reyes, 2008). In fact, in the Italian and Spanish studies, contrary to expectations, reading words with irregular stress was faster than reading words with regular stress. Additional results failing to support the idea that there is a strong default mechanism of regular stress assignment have been provided by Colombo and Zevin (2009). Using a 'pathway priming' methodology, in which participants named a target word preceded by a set of words that either had or did not have the same stress pattern as the target, the researchers demonstrated that participants were more likely to be impacted by the stress pattern of the primes than by the knowledge of a more frequent stress pattern in the language.

In addition, the usefulness of thinking of stress regularity as being based simply on the most frequently encountered pattern of stress in a language has been questioned (Kelly & Bock, 1988). Those researchers, instead, suggested that, in evaluating stress regularity, the distribution of stress patterns in words of different grammatical categories should be considered. For instance, in English, first-syllable (trochaic) stress is more typical in nouns, whereas most disyllabic verbs exhibit second-syllable (iambic) stress. Therefore, it may be better to consider nouns with trochaic stress and verbs with iambic stress as having regular stress in English. Empirical evidence for the impact of grammatical category on stress assignment has been provided by experiments involving reading non-words embedded in verb vs. noun biasing contexts (Kelly & Bock, 1988) and involving processing words during auditory and visual word recognition (Arciuli & Cupples, 2004, 2006). For example, Arciuli and Cupples (2004), using an onset-gating paradigm, in which regularly (trochaic nouns and iambic verbs) and irregularly (iambic nouns and trochaic verbs) stressed words were presented in increasing increments, showed that participants were

better at identifying words with a more frequent stress pattern. Further, Arciuli and Cupples (2006) showed that typically stressed trochaic nouns and iambic verbs that were presented visually without any contextual support also enjoyed a processing advantage over atypically stressed iambic nouns and trochaic verbs in naming and lexical decision tasks. The conclusion, therefore, is that, although there is evidence that when reading in a language involving a regular stress pattern, readers may have a tendency to apply a more frequent stress pattern by default, it is still unclear how important stress regularity is, and whether a word's grammatical category also needs to be considered in assessing the regularity of stress patterns.

Stress consistency

Stress consistency, defined as an association of orthography with stress patterns, might also impact word processing. If the majority of words containing a given cluster of letters has a different stress pattern than the pattern in the word being read (the word's 'stress enemies'), processing may be slowed down compared to cases where the word being read has the same stress pattern as words with a similar combination of letters ('stress friends'). An experimental investigation of stress consistency in Italian demonstrated not only a consistency effect but an interaction with stress regularity (Colombo, 1992). While stress consistency had no impact on the processing of regularly stressed words, words with an irregular stress pattern were affected by stress consistency. Specifically, words with an irregular but consistent stress pattern were named as fast as regularly stressed words, whereas irregularly and inconsistently stressed words required the longest period of time to name. This finding of an interaction between stress regularity and stress consistency also emerged in a simulation of Italian word naming produced by a connectionist model of reading (Pagliuca & Monaghan, 2010).

Burani and Arduino (2004) challenged Colombo's (1992) conclusions, claiming that Colombo's stimuli were not well matched on a number of variables including summed frequency of neighbours and initial phoneme characteristics. Burani and Arduino reported that the performance of readers on naming their better matched Italian words that varied in stress consistency and stress regularity showed a significant consistency effect in both regularly and irregularly stressed words with no interaction. Words with many stress friends were read faster and with fewer mistakes than words that had many stress enemies. Further, there was no overall regularity effect. A similar suggestion that stress assignment in Italian is driven by distributional information about the consistency of the stress pattern rather than by a default assignment of a more frequent stress pattern has been made by Sulpizio, Arduino, Paizi, and Burani (2013).

Performance on regularly and irregularly stressed words with different degrees of stress consistency was also examined in English (Arciuli & Cupples, 2006). In contrast to the results in Italian, Arciuli and Cupples initially found that regularly or what they called typically stressed words defined according to grammatical category (i.e., nouns with trochaic stress and verbs with iambic stress) were named faster than atypically stressed words (i.e., nouns with iambic stress and verbs with trochaic stress). In a further analysis of a corpus of English disyllabic words, those researchers also demonstrated that English word endings are probabilistically associated with certain stress patterns as well as with certain grammatical categories. Therefore, typically stressed English words may enjoy a processing advantage due to the fact that in these cases orthographic cues are often consistent with one another in terms of providing the correct combination of grammatical category and stress pattern information.

The important point to make here is that additional information concerning the impact of stress consistency in reading polysyllabic words is required. At the moment, it is unclear whether stress consistency is in fact a dominant cue to stress as suggested by Burani and Arduino (2004), whether its role is limited as it affects irregularly stressed words only (Colombo, 1992), or whether it assists readers in stress assignment in some other fashion, for example, by providing consistent cues to grammatical categories and stress patterns (Arciuli & Cupples, 2006).

Aims of the current research

Assignment of lexical stress in Russian is an underinvestigated but promising area of research. There are two main questions that we addressed in the present studies. The first is the general question of how stress is assigned in Russian. As noted, it has been argued that Russian stress assignment can only be accomplished by retrieving the relevant information from memory following lexical access (Gouskova, 2010; Lukyanchenko et al., 2011). Based on work in other languages showing the impact of various cues to stress, however, it seemed unlikely that the assignment of word stress in Russian would be purely the result of lexical processing. At a general level, therefore, one of our goals was to determine if there is evidence for the influence of non-lexical factors in the process of stress assignment in Russian. The second, and more specific, aim of the

current research was to focus on the impact of two particular stress cues: stress regularity and stress consistency. The fact that there appears to be no regular stress pattern in Russian, except when one considers grammatical categories individually allows us to conduct a more discriminating analysis of these two cues. This investigation should lead to more general conclusions about the mechanisms of stress assignment that should be taken into consideration by models of polysyllabic word reading.

In Study 1, we investigated the distribution of trochaic vs. iambic stress patterns in a corpus of Russian disyllabic words to substantiate the claims that (1) there is no overall bias for a particular stress pattern in Russian and (2) that stress regularity could be found in Russian at the level of grammatical categories. The purpose of Studies 2 and 3 was to determine the extent to which stress regularity (at the level of grammatical category) and stress consistency affect the performance of native speakers of Russian on disyllabic words. In Study 2, participants were asked to name words that differed in stress patterns (trochaic vs. iambic), grammatical category (nouns vs. verbs vs. adjectives), and consistency (consistent vs. inconsistent). In Study 3, the same stimuli were used in a lexical decision task to determine whether there would be regularity and/or consistency effects when the activation of phonological information is not required. Stress consistency was defined in terms of the consistency of the relationship between the word's ending and its stress (Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995).

Study 1 – corpus analysis

Method

All disyllabic words from the Frequency Dictionary of Modern Russian (Lyashevskaya & Sharov, 2009) were selected. There were 8064 disyllabic words, which accounted for 19% of all words in the dictionary. The dictionary provides lemmatized forms of the words only. In the morphologically rich Russian language, however, readers are exposed to inflected forms more often than to lemmatized forms. Therefore, inflected forms of words were retrieved from the Dictionary of Russian Grammar (Zaliznyak, 2003) and added to the database. Only words with a frequency of at least 1 per million words according to the Russian National Corpus (http://ruscorpora.ru) were considered. The resulting database consisted of 13,329 words. The information about the grammatical category of each word was retrieved from the Frequency Dictionary of Modern Russian (Lyashevskaya & Sharov, 2009). The stress pattern information was verified by consulting the Dictionary of Russian Lexical Stress (Zarva, 2001).

Results and discussion

Table 1 shows the relative proportion of each stress pattern for the words in the database. Given the extremely large size of our sample, these values can be taken as good estimates of stress position distribution in Russian disyllabic words. Overall, there is no dominance of a specific stress pattern (trochaic: 55% vs. iambic: 45%). The analysis of the distribution of stress patterns in words of various grammatical categories demonstrated an empirically interesting but not unexpected pattern. Adjectives frequently had trochaic stress (80%). Verbs, in contrast, more often had iambic stress (60%). For nouns, trochaic stress occurred approximately as often as iambic stress (55% vs. 45%). Other grammatical categories (preposition, pronoun, adverb, etc.) showed an approximately 50:50 split, although the number of words in each of these categories was small.

Based on these data, it appears that Russian does not possess a regular stress pattern. At the same time, there is a dominance of the trochaic stress pattern for adjectives which potentially might influence the processing of words belonging to that grammatical category. A small dominance of the opposite, iambic stress

Table 1. Number and proportion of each stress type for Russian disyllabic words in the corpus.

	Trochaic stress		Iambic stress	
Grammatical category	Number	Proportion (%)	Number	Proportion (%)
Adjective	1711	80	430	20
Noun	4450	55	3710	45
Verb	1053	40	1607	60
Other	177	49	187	51
Total	7395	55	5934	45

Note: The stress type proportions are calculated based on the total number of words in the grammatical category in question contained in the corpus. Trochaic stress refers to stress on the first syllable of a word. Iambic stress refers to stress on the second syllable of a word.

pattern does exist for verbs. Finally, there is no regular stress pattern for nouns.

Study 2 – naming of polysyllabic words

The purpose of Study 2 was to examine the role that stress regularity and stress consistency play in Russian word naming. As noted, inconclusive results were reported in the studies that examined the effect of these variables on reading performance in other languages (Arciuli & Cupples, 2006; Burani & Arduino, 2004; Colombo, 1992). The overall balanced distribution of stress patterns in Russian makes it an interesting language to use in investigating the issues of regularity and consistency as cues to lexical stress. As Russian does not have a dominant stress pattern, readers cannot use it as a reliable cue in the processing of disyllabic words. Therefore, if all other variables are equated, latency differences in reading words with first vs. second-syllable stress are unlikely to be found in Russian. In Study 2, we were also able to examine the impact of regularity as a function of grammatical category. The evidence for a stress regularity effect at the level of grammatical category in Russian (i.e., a processing advantage for trochaic adjectives) would demonstrate that this pattern is a universal rather than an English-specific phenomenon (Arciuli & Cupples, 2004, 2006).

The other issue investigated in Study 2 concerns the reliance of readers on the consistency of the relationship between certain orthographic patterns and stress assignment. Previous research has not fully established whether the differential latencies observed in naming of polysyllabic words reflect the effect of consistency of stress, regularity of stress, or the combined effects of consistency and regularity. Because Russian nouns do not possess a regular stress pattern, those words should provide good grounds for examining the impact of consistency uncontaminated by regularity effects. If consistency matters, there should be faster response times to nouns that have consistent stress patterns. In contrast, adjectives, and possibly verbs, having a regular stress pattern will allow an examination of the interaction of regularity and consistency in the same experiment.

The final issue evaluated concerns the more general claim that stress is assigned to words in Russian only as a result of lexical retrieval (Gouskova, 2010). If so, no significant differences in the processing times and accuracy of stress assignment as a function of consistency or regularity should emerge for words in any grammatical category. In contrast, the demonstration of an impact of regularity and/or consistency on word naming would signal utilisation of non-lexical information by readers.

Method

Participants

Twenty-eight undergraduate students from Altay State University (Barnaul, Russia) took part in this experiment for a small monetary remuneration (age 17–35; $M = 19$). All were native speakers of Russian. None of the participants reported high proficiency in any second language.

Materials

A set of 192 disyllabic words (see Appendix) was created by crossing the factors of grammatical category (adjective vs. noun vs. verb), stress consistency (consistent vs. inconsistent), and stress type (first-syllable stress vs. second-syllable stress). The majority of words selected for this experiment were in their inflected forms. Only six of the selected words were in their original lemmatized form, and these were reasonably equally distributed across grammatical categories, consistency and stress type. None of the words contained morphemes that are associated with only one stress pattern; thus, the decisions about proper stress could not be biased by morphology. The stress pattern of each word was determined by consulting the Dictionary of Russian Lexical Stress (Zarva, 2001). Stimuli were 4–7 letters long. Only the items with a frequency less than 20 per million as reported in the Frequency Dictionary of Modern Russian (Lyashevskaya & Sharov, 2009) were used. The sets were matched on length, word frequency, orthographic neighbourhood size (Coltheart, Davelaar, Jonasson, & Besner, 1977), and, in a word-by-word manner, on initial phoneme characteristics. Because it is unclear whether imageability affects performance in visual word recognition tasks (Cortese & Khanna, 2007; Zevin & Balota, 2000), no attempt was made to match the words on imageability. A post hoc analysis did show that nouns were rated as more imageable than adjectives or verbs. However, imageability did not vary as a function of consistency or regularity.

The consistency measures were calculated using the database created in Study 1. Consistency was based on the neighbourhood created by words sharing an ending (i.e., the vowel of the second syllable and all following consonants). Words in the neighbourhood that had the same stress patterns were categorised as stress friends. Stress enemies were neighbour words with the opposite stress pattern. The method for calculating spelling-stress consistency was analogous to that used by Treiman et al. (1995) for spelling-sound consistency. The type consistency measure for each word was calculated as the number of stress friends divided by the number of all words with the same ending. The calculation of token consistency was carried out by

Table 2. Mean characteristics of the words with consistent spelling-to-stress mappings used in Studies 2 and 3.

	Adjectives		Nouns		Verbs	
Characteristics	Trochaic stress	Iambic stress	Trochaic stress	Iambic stress	Trochaic stress	Iambic stress
Words	16	16	16	16	16	16
Length	5.63	5.50	5.25	5.44	5.38	5.63
Frequency	3.27	2.82	3.37	3.32	3.03	3.17
N-size	2.69	3.31	3.88	2.88	3.31	3.06
Imageability	4.03	4.55	4.59	5.11	4.08	4.17
Type consistency	0.70	0.76	0.70	0.69	0.69	0.76
Token consistency	0.74	0.70	0.66	0.69	0.67	0.71

Note: Trochaic stress refers to stress on the first syllable of a word. Iambic stress refers to stress on the second syllable of a word.

dividing the summed frequency of friends by the summed frequency of all words with the same ending.[1]

Words in conditions with consistent spelling-to-stress mappings were matched on type ($M = 0.72$) and token consistency ($M = 0.69$). Words in conditions with inconsistent spelling-to-stress mapping were also matched on these measures (type consistency: $M = 0.35$; token consistency: $M = 0.36$). Word with consistent vs. inconsistent spelling-to-stress mappings differed significantly from each other when type, $F(1,191) = 1155.94$, $p < 0.001$, as well as token, $F(1,191) = 241.79$, $p < 0.001$, measures were compared. The mean characteristics of the word sets are shown in Table 2 for words with consistent spelling-to-stress mappings and in Table 3 for words with inconsistent spelling-to-stress mappings.

The 192 experimental items were inserted into a list with 108 disyllabic filler words. The filler words had equal proportions of trochaic and iambic stress to reflect the absence of a dominant stress pattern in the Russian language. The number of filler words belonging to a specific grammatical category was varied to replicate the proportion of words of each category in the language across all the words in the experiment. The distribution of stress within words of a certain grammatical category essentially reflected the frequency of stress type within each grammatical category.

Procedure

Participants were instructed that words, preceded by a fixation point, would be presented on the screen one at a time and that their task was to read those words aloud as quickly and as accurately as possible. Instructions and stimuli were presented, and naming latencies were recorded to the nearest millisecond, using the DMDX display system (Forster & Forster, 2003).

The list of 300 items was presented in three blocks of trials. There was a preceding practice block of 20 words. Every participant received all three blocks of trials. The order of blocks and of items within blocks was randomised for each participant. Each trial started with the presentation of a fixation point for 500 ms. The target word in upper-case appeared in white on a black background (Courier New, 12 font) for 2000 ms or until the participant responded. The intertrial interval was 1000 ms.

Results

Responses were marked using CheckVocal (Protopapas, 2007) by the first author and by two other native speakers of Russian who were unaware of the purpose of the experiment. Word naming times were recorded in milliseconds and errors were noted. Errors included responses with incorrect stress assignment, mispronunciations, and

Table 3. Mean characteristics of the words with inconsistent spelling-to-stress mappings used in Studies 2 and 3.

	Adjectives		Nouns		Verbs	
Characteristics	Trochaic stress	Iambic stress	Trochaic stress	Iambic stress	Trochaic stress	Iambic stress
Words	16	16	16	16	16	16
Length	5.31	5.38	5.50	5.31	5.44	5.31
Frequency	2.96	3.35	3.58	3.22	3.47	2.85
N-size	2.94	3.50	2.53	3.63	3.00	3.38
Imageability	4.16	4.11	5.23	5.37	4.41	4.30
Type consistency	0.36	0.35	0.36	0.36	0.33	0.37
Token consistency	0.39	0.35	0.34	0.36	0.36	0.36

Note: Trochaic stress refers to stress on the first syllable of a word. Iambic stress refers to stress on the second syllable of a word.

false starts. To reduce the effects of outliers, any latencies slower than 1500 ms or faster than 200 ms were discarded from the analyses. The total percentage of discarded data-points was 2.4%.

Participants' mean latencies and error rates were analysed using 2 (*stress type*: first-syllable stress vs. second-syllable stress) by 2 (*stress consistency*: consistent vs. inconsistent) by 3 (*grammatical category*: adjectives vs. nouns vs. verbs) analyses of variance (ANOVA) which were conducted using subjects as a random factor (F_1) with stress type, consistency, and grammatical category as repeated measures factors, as well as using items as a random factor (F_2) with the same variables treated as between-items factors. The results for the latencies and errors are shown in Table 4.

In line with expectations, latencies to words with first-syllable stress ($M = 684$ ms, $SD = 42$) did not differ significantly from latencies to words with second-syllable stress ($M = 686$ ms, $SD = 41$), $F_1(1,27) = 1.04$, $p = 0.32$, $\eta^2 = 0.04$; $F_2(1,180) = 0.20$, $p = 0.65$, $\eta^2 = 0.01$. However, participants were slightly more likely to make stress-assignment errors on the words with second-syllable stress (7.1%) than on the words with first-syllable stress (4.5%), $F_1(1,27) = 9.24$, $p = 0.005$, $\eta^2 = 0.26$; $F_2(1,180) = 4.5$, $p = 0.04$, $\eta^2 = 0.03$. Also as expected, there was a main effect of consistency in the analyses of latencies, $F_1(1,27) = 22.94$, $p < 0.001$, $\eta^2 = 0.46$; $F_2(1,180) = 8.56$, $p = 0.004$, $\eta^2 = 0.05$, and in the analyses of errors, $F_1(1,27) = 34.92$, $p < 0.001$, $\eta^2 = 0.56$; $F_2(1,180) = 21.52$, $p < 0.001$, $\eta^2 = 0.11$. Participants were faster ($M = 676$ ms, $SD = 37$) and more accurate (3% errors) in naming words with stress consistent endings in comparison to words with stress inconsistent endings ($M = 693$ ms, $SD = 44$; 8.6% errors). The main effect of grammatical category was also significant in both the latency, $F_1(2,27) = 16.54$, $p < 0.001$, $\eta^2 = 0.56$; $F_2(2,180) = 7.35$, $p = 0.001$, $\eta^2 = 0.08$, and error analyses, $F_1(2,27) = 18.28$, $p < 0.001$, $\eta^2 = 0.58$; $F_2(2,180) = 7.28$, $p = 0.001$, $\eta^2 = 0.08$. Planned contrasts were carried out to compare mean latencies and error rates for the three grammatical categories. The mean latency for nouns ($M = 700$ ms, $SD = 44$) was significantly larger than for adjectives ($M = 673$ ms, $SD = 38$), $F_1(1,27) = 34.36$, $p < 0.001$, $\eta^2 = 0.56$; $F_2(1,126) = 12.09$, $p = 0.001$, $\eta^2 = 0.09$, or verbs ($M = 681$ ms, $SD = 34$), $F_1(1,27) = 12.15$, $p = 0.002$, $\eta^2 = 0.31$; $F_2(1,126) = 6.23$, $p = 0.02$, $\eta^2 = 0.05$. The difference in naming latencies for verbs compared to adjectives was marginal but only in the subject analysis, $F_1(1,27) = 3.71$, $p = 0.06$, $\eta^2 = 0.12$; $F_2(1,126) = 1.69$, $p = 0.20$, $\eta^2 = 0.01$. The error rate for nouns (9.1%) was also significantly higher than for adjectives (4.0%), $F_1(1,27) = 24.66$, $p < 0.001$, $\eta^2 = 0.48$; $F_2(1,126) = 9.54$, $p = 0.003$, $\eta^2 = 0.07$, or verbs (4.2%), $F_1(1,27) = 35.66$, $p < 0.001$, $\eta^2 = 0.57$; $F_2(1,126) = 7.94$, $p = 0.01$, $\eta^2 = 0.06$. There was no significant difference in error rates for adjectives vs. verbs, $F_1(1,27) = 0.05$, $p = 0.82$, $\eta^2 = 0.01$; $F_2(1,126) = 0.02$, $p = 0.89$, $\eta^2 = 0.01$.

The only interaction that reached significance in latency analyses was between stress type and consistency in the subject but not the item analysis, $F_1(1,27) = 5.64$, $p = 0.03$, $\eta^2 = 0.17$; $F_2(1,180) = 1.10$, $p = 0.30$, $\eta^2 = 0.01$. The effect of consistency on naming times was larger for words with stress on the second syllable. This interaction between consistency and stress type did not reach significance in error data, $F_1(1,27) = 2.41$, $p = 0.13$, $\eta^2 = 0.08$; $F_2(1,180) = 0.76$, $p = 0.39$, $\eta^2 = 0.01$. All other interactions were not significant (all $Fs < 1$). Given that Russian does not have a regular type of stress; the source of the stress type by consistency interaction was puzzling. One possibility for consideration is that the interaction is driven mainly by adjectives, a grammatical class that does have a regular stress. To examine this idea, the latencies and error rates of each grammatical category were analysed separately using ANOVAs with consistency and stress type as repeated measures (F_1) or between-item factors (F_2).

For adjectives, there was a main effect of stress type in the subject latency analysis ($M = 668$ ms, $SD = 37$ vs. $M = 679$ ms, $SD = 39$), $F_1(1,27) = 4.12$, $p < 0.05$, $\eta^2 = 0.13$; $F_2(1,60) = 1.32$, $p = 0.25$, $\eta^2 = 0.02$; and in the subject and item analyses of errors (2.4% vs. 5.7%),

Table 4. Mean response times (RTs) and percentage of errors as a function of type of stress, consistency of stress and grammatical category in Study 2 (word naming).

	Trochaic stress				Iambic stress			
	Consistent		Inconsistent		Consistent		Inconsistent	
Grammatical category	RT	%Error	RT	%Error	RT	%Error	RT	%Error
Adjectives	667	1.1	668	3.1	663	3.6	693	8.5
Nouns	689	4.7	709	11.6	690	6.9	710	13.4
Verbs	678	1.2	689	5.8	668	1.6	691	8.4
Overall	678	2.3	689	6.8	674	4.0	698	10.1

Note: N=28. Trochaic stress refers to stress on the first syllable of a word. Iambic stress refers to stress on the second syllable of a word. Response times (RTs) are reported in ms.

$F_1(1,27) = 7.16$, $p = 0.001$, $\eta^2 = 0.38$; $F_2(1,60) = 10.21$, $p = 0.002$, $\eta^2 = 0.15$. The main effect of consistency was also significant in the subject latency analysis ($M = 666$ ms, $SD = 32$ vs. $M = 693$ ms, $SD = 44$), $F_1(1,27) = 9.69$, $p = 0.004$, $\eta^2 = 0.26$; $F_2(1,60) = 2.17$, $p = 0.15$, $\eta^2 = 0.04$, as well as in the subject and item analyses of errors (2% vs. 6%), $F_1(1,27) = 13.98$, $p < 0.001$, $\eta^2 = 0.56$; $F_2(1,60) = 12.62$, $p < 0.001$, $\eta^2 = 0.17$. Most importantly, there was a significant interaction between stress type and consistency for adjectives in the subject latency analysis, $F_1(1,27) = 5.3$, $p = 0.03$, $\eta^2 = 0.17$; $F_2(1,60) = 1.73$, $p = 0.19$, $\eta^2 = 0.03$, and in the subject and item analyses of errors, $F_1(1,27) = 22.62$, $p < 0.001$, $\eta^2 = 0.46$; $F_2(1,60) = 5.12$, $p = 0.03$, $\eta^2 = 0.08$. The consistency effect was larger for irregularly stressed adjectives (i.e., those with stress on the second syllable) than for adjectives with stress on the first syllable. For nouns, the only significant main effect was that of consistency in the subject latency analysis ($M = 690$ ms, $SD = 45$ vs. $M = 710$ ms, $SD = 48$), $F_1(1,27) = 12.92$, $p < 0.001$, $\eta^2 = 0.32$; $F_2(1,60) = 2.84$, $p = 0.09$, $\eta^2 = 0.05$; and in the subject and item analyses of errors (5.8% vs. 12.4%), $F_1(1,27) = 17.67$, $p < 0.001$, $\eta^2 = 0.42$; $F_2(1,60) = 5.99$, $p = 0.02$, $\eta^2 = 0.11$. Neither the main effect of stress type nor the interaction of consistency and stress type were significant (all $Fs < 1$). For verbs, there was a significant main effect of consistency in the latency analyses ($M = 673$ ms, $SD = 30$ vs. $M = 690$ ms, $SD = 36$), $F_1(1,27) = 11.51$, $p = 0.002$, $\eta^2 = 0.30$; $F_2(1,60) = 4.01$, $p = 0.05$, $\eta^2 = 0.06$, and in the error analyses (1.0% vs. 7.4%), $F_1(1,27) = 22.89$, $p < 0.001$, $\eta^2 = 0.45$; $F_2(1,60) = 10.92$, $p = 0.002$, $\eta^2 = 0.17$. Neither the main effect of stress type nor the interaction of stress type with consistency were significant for errors (main effect of type of stress: $F_1(1,27) = 2.66$, $p = 0.12$, $\eta^2 = 0.09$; $F_2(1,60) = 0.81$, $p = 0.37$, $\eta^2 = 0.01$; interaction of stress type and consistency: $F_1(1,27) = 1.88$, $p = 0.18$, $\eta^2 = 0.07$; $F_2(1,60) = 0.31$, $p = 0.58$, $\eta^2 = 0.01$).

Discussion

The hypothesis that differences in processing of disyllabic words with first vs. second syllable stress are unlikely to appear in Russian due to the absence of an overall regular stress pattern in that language was generally supported. There was no evidence of an overall latency difference between trochaically- and iambically-stressed words. Although participants did make more stress-assignment errors in naming words with second-compared to first-syllable stress, this difference was small in size (less than 1 error per participant). More importantly, this difference appears to be driven by adjectives, words that do have a regular stress. That is, the presence of a more frequent stress pattern for adjectives, and consequently more accurate processing of adjectives with this regular type of stress, appears to be what caused the overall stress type effect in the error data.

The fact that adjectives seem to be mainly responsible for the small stress type effect in the error data supports the idea that stress regularity can be based on the information about typical patterns of stress for each grammatical category. Further evidence comes from the separate analyses of the grammatical categories. A stress type effect was not realised for either nouns or verbs, presumably due to the absence of a regular stress pattern for words from these grammatical categories. In contrast, readers were not only faster and more accurate in naming Russian adjectives than naming nouns and verbs, but they also showed a stress type effect, with shorter latencies and fewer errors when naming regular first-syllable stress adjectives than when naming irregular second-syllable stress adjectives.

The effect of consistency of stress pattern was also successfully demonstrated. Words that contained endings representative of these words' stress patterns were named faster and more accurately than words that had endings signalling a stress pattern different than the pattern that to-be-named words had. This effect remained significant even when an analysis at the level of each grammatical category was conducted. In addition, in the analysis of adjectives, an interaction of consistency and stress type was found. Consistency had no effect on adjectives with regular trochaic stress, while adjectives with infrequent iambic stress showed a consistency effect. Irregularly stressed iambic adjectives that had endings associated with trochaic stress required a longer time for naming than adjectives in any other condition. This interaction of stress type and consistency was observed only for adjectives. For nouns and verbs, only a consistency main effect was observed. Therefore, it is clear that stress consistency is an important cue in stress assignment. Consistency seems to interact with regularity of stress if a certain stress pattern is more frequent, and it acts as a main cue if there is no dominant stress pattern.

Finally, with respect to the more general question of how stress is assigned in Russian, Study 2 provided evidence that this process is not simply a lexically-based one. Instead, when naming Russian words, readers use non-lexical information, in particular, the knowledge of a regular stress pattern as defined within the word's grammatical category, and of the consistency with which a word ending maps onto a stress pattern.

Study 3 – lexical decision task

The aim of Study 3 was to determine whether consistency and regularity of stress play significant roles in word identification in general, that is, in a situation in which the task does not require explicit

retrieval of words' phonological representations. Previous studies examining the effect of stress consistency and regularity in the lexical decision task provided conflicting results. While Colombo (1992) failed to find a regularity effect in her latency analysis using this task, Kelly, Morris, and Verrekia (1998) reported differential performance on words with regular vs. irregular stress, but the effect was observed in the opposite direction than expected, with irregularly stressed words enjoying a processing advantage. Similarly, there is contrasting evidence concerning the existence of a stress consistency effect in the lexical decision task. In a study by Burani and Arduino (2004), spelling-to-stress consistency played no important role. On the other hand, Kelly et al. (1998) did report a stress consistency effect in a lexical decision task in English. The presence of orthographic patterns consistent with a second-syllable stress facilitated decisions on words with this type of stress and inhibited responses to words with first-syllable stress.

Study 3 was an attempt to investigate the nature of stress regularity and stress consistency effects in Russian in a lexical decision task. We did not expect any overall stress type effect as a more regular stress pattern is absent in the language. If type of stress has any effect in Study 3, it would likely be found in the analysis of adjectives which have a regular, first-syllable stress. An overall consistency effect might be observed, particularly if phonological information is used in making lexical decisions. However, since the task is not phonological in nature, it is quite possible that words with consistent vs. inconsistent spelling-to-stress mappings would not be processed differently.

Method

Participants

Forty undergraduate and graduate students from Altay State University (Barnaul, Russia) took part in this experiment for a small monetary remuneration (age 19–33; $M = 20$). None of them took part in Study 2. All were native speakers of Russian.

Materials

The 192 experimental target words used in Study 2 were also used in this study. In addition, 192 non-words were used. The non-words were created by changing two internal letters in target words. The original word endings that often correspond in Russian to inflectional or derivational morphemes were kept unchanged. Otherwise, the readers could have used the existence of those morphemes to distinguish between words and non-words. The non-words were pronounceable and did not contain any orthographically illegal combinations of letters. Thus, lexical decisions also could not be made based on orthographic information alone.

Procedure

The participants had to indicate whether each displayed letter string was a word or a non-word as fast and as accurately as possible by pressing one of two keys. Instructions and stimuli were presented and latencies were recorded to the nearest millisecond using the DMDX display system (Forster & Forster, 2003). The list of 384 items was presented in three blocks of trials. The items were divided into the blocks in such a way that a target word and the non-word that was created from it did not appear in the same block of trials. There was a preceding practice block of 10 words and 10 non-words. Every participant received all three blocks of trials. The order of blocks and of items within blocks was randomised for each participant. Each trial started with the presentation of a fixation point for 400 ms. The target word in uppercase appeared in white on a black background (Courier New, 12 font) for 1500 ms or until participants responded. The intertrial interval was 1500 ms.

Results

To reduce the effects of outliers, latencies slower than 1500 ms or faster than 200 ms were discarded from the analyses. The total percentage of discarded data-points was 2.9%. Participants' mean latencies and error rates for word targets were analysed using the same analyses as in Study 2. The results for the response times and the errors are shown in Table 5.

There was a lexicality effect both in the analyses of latencies, $F_1(1,39) = 79.91$, $p < 0.001$, $\eta^2 = 0.67$; $F_2(1,384) = 233.37$, $p < 0.001$, $\eta^2 = 0.38$, and of errors, $F_1(1,39) = 4.01$, $p = 0.05$, $\eta^2 = 0.09$; $F_2(1,384) = 20.76$, $p < 0.001$, $\eta^2 = 0.05$, with participants responding slower and less accurately to non-words compared to words (non-words: $M = 920$ ms, $SD = 26$, 8.4% errors vs. words: $M = 820$ ms, $SD = 22$, 5.8% errors).

In the analyses of word targets, there was no main effect of stress type either in latencies, $F_1(1,39) = 0.22$, $p = 0.64$, $\eta^2 = 0.01$; $F_2(1,180) = 0.11$, $p = 0.74$, $\eta^2 = 0.01$; or in errors, $F_1(1,39) = 0.16$, $p = 0.84$, $\eta^2 = 0.01$; $F_2(1,39) = 0.01$, $p = 0.91$, $\eta^2 = 0.05$. Similarly, the consistency of the spelling-to-stress mapping did not have any significant effect on either latencies, $F_1(1,39) = 2.09$, $p = 0.16$, $\eta^2 = 0.05$; $F_2(1,180) = 0.12$, $p = 0.73$, $\eta^2 = 0.01$, or errors, $F_1(1,39) = 0.04$, $p = 0.84$, $\eta^2 = 0.01$; $F_2(1,180) = 0.03$, $p = 0.87$, $\eta^2 = 0.05$. On the other hand, the main effect of grammatical category was significant in the latency analyses, $F_1(2,38) = 19.15$, $p < 0.001$, $\eta^2 = 0.50$; $F_2(2,180) = 3.76$, $p = 0.03$, $\eta^2 = 0.04$, and in the subject analysis of accuracy, $F_1(2,38) = 6.25$, $p = 0.004$, $\eta^2 = 0.25$; $F_2(2,180) = 1.50$, $p = 0.27$, $\eta^2 = 0.02$.

Table 5. Mean response times (RTs) and percentage of errors as a function of type of stress, consistency of stress and grammatical category in Study 3 (lexical decision task).

	Trochaic stress				Iambic stress			
	Consistent		Inconsistent		Consistent		Inconsistent	
Grammatical category	RT	%Error	RT	%Error	RT	%Error	RT	%Error
Adjectives	798	3.6	789	3.5	800	4.2	822	7.4
Nouns	835	7.0	839	7.3	836	6.2	839	7.0
Verbs	821	6.0	830	5.2	815	4.8	820	6.0
Overall	818	5.5	819	5.3	817	5.0	827	6.8

Note: N=40. Trochaic stress refers to stress on the first syllable of a word. Iambic stress refers to stress on the second syllable of a word. Response times (RTs) are reported in ms.

To analyse the grammatical category effect, a set of planned contrasts was carried out. Adjectives ($M=804$ ms, $SD=22$) were identified as words faster than verbs ($M=822$ ms, $SD=22$), $F_1(1,39)=5.92$, $p=0.02$, $\eta^2=0.25$; $F_2(1,126)=3.38$, $p=0.07$, $\eta^2=0.03$; or nouns ($M=837$ ms, $SD=22$), $F_1(1,39)=37.86$, $p<0.001$, $\eta^2=0.49$; $F_2(1,126)=9.10$, $p=0.003$, $\eta^2=0.07$. The difference in latency between verbs and nouns was also significant in the subject analyses, $F_1(1,39)=5.69$, $p=0.02$, $\eta^2=0.13$; $F_2(1,126)=0.63$, $p=0.43$, $\eta^2=0.01$. The relative ease of processing of adjectives compared to the other groups was also revealed in the error analyses. Adjectives produced fewer errors (4.7%) than nouns (7.0%), $F_1(1,39)=12.68$, $p<0.001$, $\eta^2=0.25$; $F_2(1,126)=3.75$, $p=0.06$, $\eta^2=0.03$. The difference in the accuracy of processing of verbs (5.7% errors) vs. nouns (7.0% errors) was marginally significant in the subject analysis, $F_1(1,39)=3.44$, $p=0.07$, $\eta^2=0.03$; $F_2(1,126)=0.71$, $p=0.40$, $\eta^2=0.01$. There was no significant difference in error rates for adjectives vs. verbs, $F_1(1,39)=2.71$, $p=0.10$, $\eta^2=0.13$; $F_2(1,126)=0.65$, $p=0.40$, $\eta^2=0.01$.

The interaction between grammatical category and stress type was significant in the subject error analysis, $F_1(2,38)=4.19$, $p=0.02$, $\eta^2=0.18$; $F_2(2,180)=0.66$, $p=0.52$, $\eta^2=0.01$, and approached significance in the subject latency analysis, $F_1(2,38)=2.65$, $p=0.08$, $\eta^2=0.12$; $F_2(2,180)=1.05$, $p=0.35$, $\eta^2=0.02$. There were no significant interactions between grammatical category and consistency (all Fs <1.35). The interaction between stress type and consistency was significant in the analyses of errors, $F_1(1,39)=6.78$, $p=0.01$, $\eta^2=0.15$; $F_2(1,180)=3.66$, $p=0.07$, $\eta^2=0.02$, but not in the analyses of latencies, $F_1(1,39)=1.21$, $p=0.28$, $\eta^2=0.19$; $F_2(1,180)=0.45$, $p=0.50$, $\eta^2=0.01$. For words with second-syllable stress, participants were more likely to make errors to words with inconsistent rather than consistent spelling-to-stress mappings (7.5% vs. 5.0%), which was not true for words with first-syllable stress (5.5% vs. 5.3%). Finally, the three-way interaction between grammatical category, stress type and consistency was not significant (all Fs <1).

Although the interaction between grammatical category and stress type was significant only in the subject latency analysis, we considered it to be useful to assess the potential differences in the processing of adjectives, nouns and verbs due to the fact that differences did exist in Study 2. The latencies and error rates of each grammatical category were analysed separately using ANOVAs with consistency and stress type as factors. For adjectives, there was a significant main effect of stress type in the subject analyses for both latency ($M=794$ ms, $SD=22$ vs. $M=811$ ms, $SD=23$), $F_1(1,39)=4.92$, $p=0.03$, $F_2(1,60)=1.22$, $p=0.28$, $\eta^2=0.02$, and errors (3.6% vs. 5.8%), $F_1(1,39)=7.77$, $p=0.01$, $F_2(1,60)=1.81$, $p=0.18$, $\eta^2=0.03$. The main effect of consistency did not reach significance (all Fs <1). The interaction between stress type and consistency was significant in the subject analysis of the error data (latency: $F_1(1,39)=1.70$, $p=0.20$, $\eta^2=0.04$; $F_2(1,60)=0.26$, $p=0.62$, $\eta^2=0.01$; errors: $F_1(1,39)=7.10$, $p=0.01$, $\eta^2=0.16$; $F_2(1,60)=2.91$, $p=0.09$, $\eta^2=0.05$). In processing adjectives with more frequent first-syllable stress, participants were equally likely to make errors for items with consistent vs. inconsistent spelling-to-stress mappings (3.6% vs. 3.5%). For adjectives with less common second-syllable stress, stress consistency did affect performance (4.2% vs. 7.4%). The manipulation of stress type and stress consistency in nouns and verbs did not produce any significant main effects or interactions (all Fs <1).

Discussion

As expected, participants made comparable numbers of errors and required equal amounts of time for the identification of words with iambic vs. trochaic stress. However, the analysis of the stress type effect at the level of the grammatical category revealed an interesting picture. On the one hand, with respect to nouns and verbs, categories that do not have a dominant stress

pattern in the language, there were no stress type effects. On the other hand, adjectives with regular for their grammatical category first-syllable stress were processed faster and more accurately than adjectives with irregular second-syllable stress. Thus, the information about the regularity of a stress pattern, if it is present in the words of a specific grammatical category, does seem to have at least some impact in a lexical decision task. No main effect of stress consistency was found nor was there any evidence of a consistency effect in any of the grammatical categories. However, the presence of a significant interaction between stress type and consistency in the subject error analysis does not allow us to conclude unconditionally that information about stress consistency is irrelevant in the lexical decision task.

General discussion

To date, behavioural investigations of the stress-assignment process have been conducted in a limited number of languages, languages that are all characterised by the presence of a dominant stress pattern that is believed to create a bias in assigning stress. The presence of a bias of this sort complicates the investigation of other factors as it becomes difficult to disentangle the effect of the bias from the effects of other potential cues to stress. This paper presents findings from a corpus analysis and two behavioural investigations conducted in Russian, a language in which the assumption has been that trochaic and iambic stress patterns occur approximately equally often. Our analysis of the corpus of Russian disyllabic words provided evidence substantiating that assumption and, hence, suggesting that Russian readers would have no reason to demonstrate an overall bias towards either stress type. Further analysis of the distribution of stress patterns in words of various grammatical categories revealed that, although the distribution of stress types in Russian nouns and verbs was not greatly different from the distribution observed in the language overall, a trochaic stress pattern was more frequent than an iambic stress pattern in adjectives. Thus, Russian provides a unique opportunity to observe, within the same language, the behaviour of readers in situations when there is a regular stress pattern that could create a stress assignment bias (i.e., in case of adjectives), and when there is no bias due to the absence of a regular stress pattern (i.e., in case of nouns and potentially verbs).

For this difference in the distribution of stress patterns for adjectives, nouns and verbs to have an impact in our experimental tasks, it would seem to be necessary that information about grammatical category becomes available early in processing, specifically before stress information could be retrieved following a successful lexical access. Prior research on grammatical category effects in isolated word recognition does, indeed, suggest that grammatical category information is accessed automatically during very early stages of lexical processing (Vigliocco, Vinson, Arciuli, & Barber, 2008; Vigliocco, Vinson, & Siri, 2005). Further, grammatical category violations were shown to give rise to event-related potential (ERP) responses as early as 150 ms post stimulus presentation (Bornkessel & Schlesewski, 2006; Federmeier, Segal, Lombrozo, & Kutas, 2000). It has also been demonstrated that readers use an array of phonological (e.g., length in phonemes; length in syllables; onset complexity etc.) and orthographic cues (e.g., bigram co-occurrences, word ending patterns etc.) to grammatical category (Monaghan, Chater, & Christiansen, 2005; Shi, Morgan, & Allopena, 1998). In fact, the evidence for readers' sensitivity to orthographic cues to grammatical category has been demonstrated not only at the behavioural, but also at the neural level (Arciuli, McMahon, & Zubicaray, 2012). Thus, readers appear to be aware of the grammatical category that a word belongs to very early in processing. Therefore, stress pattern information that is specific to a grammatical category may be used by readers in the stress-assignment process.

Although none of the experiments cited above had been carried out in Russian, it seems possible that information about grammatical category would also be readily available in Russian, and would assist readers of Russian in stress assignment and, potentially, in word processing in general. Indeed, the findings of Study 2 provided good evidence that probabilistic distributions of stress patterns in words of specific grammatical categories in Russian do play an important role in naming. When a certain stress type occurs more often (e.g., first-syllable stress in adjectives), readers are sensitive to this information, and appear to be biased to assign the more frequent stress pattern. The stress bias is manifested in faster response times and higher accuracy rates in the processing of adjectives with regular, first-syllable stress compared to adjectives with stress on their second syllable. On the other hand, when the probabilities of the two stress patterns are nearly equal (e.g., Russian nouns), readers do not demonstrate a preference for either stress pattern.

The lack of a regular stress pattern for nouns and verbs means that stress assignment for those words had to be based on other factors. Note that the presence of a regular stress pattern in one grammatical category put the regularly stressed words belonging to that category (which form the majority of the words in that category) into an advantageous position from the point of view of

their processing compared to the words from other grammatical categories. Significantly faster and more accurate processing of adjectives compared to nouns and verbs, as demonstrated in Study 2, serves as evidence of the facilitating effect that the presence of a regular stress pattern in the language can produce.

The effect of stress regularity for adjectives was demonstrated not only in the naming task, a task that requires the retrieval and articulation of a phonological code, but also in Study 3, using the lexical decision task, a task that does not require phonological processing. Regularly stressed trochaic adjectives were identified as words faster and more accurately than irregular iambic adjectives with there being no differences in the processing of verbs or nouns with stress on the first vs. second syllable. Moreover, similar to the naming task, the presence of stress regularity in adjectives appears to have led to faster and more accurate performance for (regularly stressed) words belonging to that grammatical category compared to words from the other grammatical categories. A stress regularity effect in a lexical decision task was previously reported by Colombo (1992), but only in the error analysis. The regularity effect in both the error and latency data in the lexical decision task reported here could reflect greater reliance of Russian readers on phonology even when phonological retrieval is not required. Alternatively, the reliance on phonological information in our lexical decision experiment could be due to the characteristics of our stimuli. In particular, the choice of low frequency words and very word-like non-words for this experiment might have made it difficult for participants to make a decision based just on information derivable from the letter strings' orthographies, causing phonology to play a major role in the process of determining a word's lexical status (for a review of phonological effects in a lexical decision task, see Halderman, Ashby, & Perfetti, 2012).

What should also be noted is that, although the stress regularity effect in adjectives and the effect of grammatical category observed here appear to be readily explained by an early activation of grammatical category information, which, in the case of adjectives, assists readers in identifying the stimuli as words, there might be an alternative explanation for these effects. One could argue that the orthographic cues to grammatical category also provide, at least in the case of adjectives, useful information concerning stress assignment. In contrast, the cues associated with nouns and verbs may not provide any useful stress-assignment information. If so, one would expect an overall adjective advantage and a stress regularity effect for adjectives but not for nouns and verbs even if the grammatical category was not actually activated early in processing. Evaluating whether this might be a better way of accounting for our effects involving grammatical category will require a more complete understanding of what the various orthographic cues are that Russian readers use for assigning both grammatical category and stress.

What the present results also showed was a significant impact of spelling-to-stress consistency in Russian word naming. However, the scope of reliance on this stress cue appears to depend on the availability of other factors. Experimental results demonstrated that participants were guided mainly by consistency cues if there was no dominant stress pattern present as in case of Russian nouns and verbs. On the other hand, in naming Russian adjectives which tend to have trochaic stress, consistency only mattered when irregularly stressed iambic adjectives had to be named (or alternatively, one could describe this pattern as indicating that regularity only mattered when considering adjectives with inconsistent endings). This pattern of results suggests that both consistency and regularity are reliable stress cues for adjectives, and that there is only a penalty to pay when neither is valid (i.e., an adjective containing an ending consistent with a first-syllable stress which, nonetheless, is stressed on the second syllable).

The finding of an interaction between stress regularity and stress consistency when naming adjectives does parallel previous results reported by Colombo (1992), who found that only irregularly stressed words were affected by the consistency of stress in a naming task in Italian. At the same time, our results stand in contrast to those from another study conducted in Italian (Burani & Arduino, 2004), showing comparable effects of stress consistency on regularly and irregularly stressed words. Burani and Arduino explained the discrepancies between their results and Colombo's by pointing to a number of characteristics of the experimental items that were not controlled properly in Colombo's experiment (i.e., type consistency, token consistency, and initial phoneme characteristics). Although the stimuli were selected for the present experiments taking into account Burani and Arduino's criticisms, we, nevertheless, obtained the same interaction that Colombo did. That is, there was a differential effect of stress consistency on regularly vs. irregularly stressed words when stress regularity is a meaningful concept (i.e., for Russian adjectives), suggesting that there may be an alternative reason why there were different patterns in the two Italian naming studies.

In contrast to regularity, which had a significant impact on participants' performance in both naming and lexical decision tasks, an impact of consistency was evident in naming but not in lexical decision. As noted above, it is possible that the regularity effects appeared in the lexical decision experiment due to the nature of the experimental items, specifically if those items encouraged participants to engage in some sort of

phonologically based verification of lexical status. If this argument is correct, however, one would expect that stress consistency, which is also a phonological factor, would also have impacted processing in Study 3. One possible explanation for why only regularity seemed to matter might be that regularity is simply a more readily accessed cue. As noted, 80% of Russian adjectives are stressed on the first syllable. Hence, there would be a clear bias to quickly apply a regular stress to adjectives, aiding processing of adjectives that actually are stressed on the first syllable. In contrast, the various endings had a wide range of consistency values. Thus, for many adjectives, consistency information might not be able to provide a strong cue early in processing. As a result, regular words might gain a bit of an advantage over irregular words when making a decision about the lexical status of items, while consistent words would enjoy much less of an advantage over inconsistent words. Consistent with this argument, in Study 3, there was at least a hint that consistency was not completely irrelevant for adjectives as there was a consistency by stress type interaction in the error data.

Finally, with respect to the general goal of this research, we have provided strong evidence against the idea that stress assignment in Russian is accomplished simply by retrieving stress information from the word's lexical representation. If this hypothesis were in fact correct, we would not expect to have seen either stress regularity or stress consistency effects. In contrast, the present experiments demonstrate that native speakers of Russian do, in fact, utilise non-lexical, distributional information about stress that assists them in naming and identifying disyllabic Russian words. That is not to deny the possibility that a reliance on the specific retrieval of word-based stress knowledge in the process of stress assignment not only exists for Russian speakers but that it may even be greater in Russian compared to other languages in which word stress is more predictable. This reliance could be especially great in case of high frequency words which were not used here. Nonetheless, the present results clearly indicate that simply retrieving a word's stress pattern from that word's lexical representation is not the only process involved in assigning stress in Russian.

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Note

1. In calculating spelling-to-stress consistency measures some researchers consider only the words of the same syllabic length (Arciuli & Cupples, 2006; Arciuli et al., 2010), while others examine all words of the language regardless of the number of syllables (Burani & Arduino, 2004; Colombo, 1992). No empirical investigation has been conducted to determine which approach provides a better reflection of the processes that take place during lexical stress assignment in word reading. We decided to use the former way of calculating spelling-to-stress consistencies as this approach appears to be more consistent with the architecture of the Connectionist Dual Process++ model (CDP++: Perry et al., 2010), a model that proposes that the processing system has information about the number of syllables of an orthographic input before stress pattern information is computed (non-lexically).

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Appendix

Russian disyllabic words used in Studies 2 and 3 as critical items.

Adjectives

Trochaic stress

Consistent: ВИДНОМ, ДИКОМ, ЖАДЕН, ТРУДЕН, КРАТКОМ, ЛЕВОМ, РЕЗКОМ, СЛАЩЕ, ТОЧЕН, ОСТРОМ, ЯСНОМ, БЕДЕН, ГЛАВНОМ, ЗЕЛЕН, ГОРДОМ, ЧЕСТЕН

Inconsistent: БАБКИН, ВЕСЕЛ, БЛИЗОК, ДЕРЗОК, ЖАЛОК, КРАТОК, КРЕПОК, МОЛОД, РОБОК, СЛАДОК, ТОНОК, УЗОК, ЯРОК, ГИБОК, ЧЁРТОВ, ВЯЗОК

Iambic stress

Consistent: КРАСИВ, НЕПРАВ, РЕВНИВ, ЗАЧАТ, ГОРБАТ, СУРОВ, СМЕШОН, ТРУСЛИВ, ТЯЖЁЛ, УНЫЛ, БОГАТ, БОЛТЛИВ, ВЫСОК, ЗАЖАТ, ГЛУБОК, ЕДИН

Inconsistent: ПЕЧНОЙ, УМНЫ, ЯСНА, БЫЛОМ, ЧУЖОМ, РАВНЫ, СВЕЖО, БЛАГИМ, ЖИЛОМ, ЗАБИТ, ГУСТОМ, ДУРНА, ЗЕМНОМ, КРУТОМ, ЛЕГКИ, ТРОЙНОМ

Nouns

Trochaic stress

Consistent: ВАЛЬСЫ, ВЕКОМ, КРОВЛИ, КРЕМОМ, МИСКИ, ЖАНРОМ, СЛОГА, ТЕСТЯ, АКЦИЙ, ЯВКИ, РУСЛОМ, БАСНЮ, БЛАНКИ, ВАЛОМ, ГАЙКИ, ЧУКЧИ

Inconsistent: ОТРОК, ЯДОВ, ГРАМОТ, ГАДОВ, ЧЕХОВ, ЛИФТОВ, МАСОК, РЫБИН, СВОДОВ, ПОШЛИН, ВЕТОК, ВЫПЛАТ, БЕСОВ, ЖЕСТОВ, КРЕСЕЛ, ПРИСТАВ

Iambic stress

Consistent: ЗАБАВ, БОРОД, ГЛУБИН, БЫЛИН, ЧИНОВ, ДЕВЧАТ, ЖИДОВ, ЗАСТАВ, ПРУЖИН, КРУЖКОВ, ЛОПАТ, МОРЩИН, СТАНКОВ, КАБИН, ОВЕЦ, ЮНЦОВ

Inconsistent: ВЕРХИ, ЯДРОМ, БАШКЕ, ГЕРБОМ, ЧУЛКИ, ЛОТКИ, МЕШКИ, СТАНКА, ТИСКИ, ИСТЦОМ, ДВОРЫ, ВОЗНИ, ДУБЫ, ЖИЛЬЦА, КРЮЧКИ, КРЫЛОМ

Verbs

Trochaic stress

Consistent: КРУТЯТ, ЛЕЗЛО, ЛЯЖЕШЬ, СБИЛИ, ПОМНИ, АХНУЛ, ЕЗДЯТ, БИЛО, ГОНЯТ, ГРЫЗЛО, ЧУЕШЬ, ВЫЙДИ, ВАЛЯТ, БУРКНЕШЬ, ЖАРЯТ, КЛАЛИ

Inconsistent: ЕЗДИЛ, ГИБНЕТ, ВЫПЕЙ, ДЛИЛИСЬ, ЧИСТИЛ, ВЕДАЛ, ВОЮТ, ДУШАТ, ЖАЖДЕТ, ПРЫГАЛ, КЛЮНУТЬ, НЮХАЛ, МЕЧЕТ, СНИМЕТ, ТОПАЛ, АХАЛ

Iambic stress

Consistent: ЯВИТЬ, ГАДАЛ, БРОСАЛ, ГОСТИЛ, ЧИНИЛ, МОЛИЛ, РЕВЕЛ, СТИРАЛ, ТОРЧАТ, УБРАЛ, ЗАДЕЛ, ВИЗЖАЛ, БЕРЕЧЬ, ЗАБИЛ, ТРЕЩАЛ, ПРОЩАЛ

Inconsistent: ВЕЗЛИ, БУДИ, ВЕЛЯТ, КЛАДИ, ВИНЯТ, ПЛЕСТИ, ЛЕГЛО, МАНИ, СНЕСТИ, ИКНУЛ, ПОЛЗТИ, ЮЛИТ, БОМБЯТ, ГОРЯТ, БЛЮСТИ, ЦАРИТ