Nonnative Processing of Verbal Morphology: In Search of Regularity

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There is little agreement on the mechanisms involved in second language (L2) processing of regular and irregular inflectional morphology and on the exact role of age, amount, and type of exposure to L2 resulting in differences in L2 input and use. The article contributes to the ongoing debates by reporting the results of two experiments on Russian verb generation and recognition in a lexical decision task (LDT) with priming by highly proficient late L2 learners, early interrupted (heritage) learners, and adult native speakers of Russian. Inflected verbs varying in regularity, type, and token (lemma) frequency were used. The experiments document the role of obligatory decomposition and complex allomorphy involved in (de)composition and mapping as well as type and token frequency in L1 and L2 verb generation and lexical access, with no sharp division between regular and irregular verbs. The results are inconsistent with either the dual-system or the single-system approach to morphological processing, and are compatible with “hybrid” theories combining rule-based decomposition and input-frequency-based probabilistic mechanisms. All of the verb types showed priming effects, both in native and nonnative lexical access. However, the degree of facilitation depended on decomposition costs for different verb types only in nonnative participants. The study also shows differences in early (heritage) and late L2 learners. In the production task, heritage speakers outperformed L2 learners in real, but not novel, verb generation and in the use of the regular default pattern, whereas L2 learners showed an advantage in
the use of the cue-based complex morphological pattern. In the priming task, heritage speakers were faster than late L2 learners and insensitive to morphological complexity, whereas L2 learners showed longer latencies in response to the verbs with complex inflectional morphology. These differences are associated with the differences in their respective language learning backgrounds. It is tentatively suggested that these two groups of learners may rely on different processing mechanisms and, possibly, neural paths.

Keywords inflectional morphology; regular and irregular verbs; Russian; decomposition; processing; frequency; priming; heritage speakers; late L2 learners

Introduction

The processing of verbal morphology by native speakers, early bilinguals, and second language (L2) learners in English and in languages with richer inflectional systems, such as Swedish (Portin, Lehtonen, & Laine, 2007b), Finnish (Lehtonen, Niska, Wande, Niemi, & Laine, 2006), Norwegian (Simonsen, 2000), Icelandic (Ragnasdóttir, Simonsen, & Plunkett, 1999), German (e.g., Clahsen, 1999; also see Clahsen, Felser, Neubauer, Sato, & Silva, this issue), Italian (Orsolini, & Marslen-Wilson, 1997), Spanish (Rodriguez-Fornells, Münte, & Clahsen, 2002), Catalan (De Diego Balaguer, Sebastián-Gallés, Diaz, & Rodriguez-Fornells, 2005), Russian (Gor & Chernigovskaya, 2001, 2005), and Polish (Dabrowska, 2004), has fueled debates on the nature of underlying cognitive processes for more than two decades. The roles of regularity, the status of symbolic rule computation as opposed to storage of inflected forms, and morphological decomposition in lexical access are even less understood in L2 acquisition. The present article explores the roles of regularity, morphological complexity, and input frequency in lexical access and (de)composition in early (heritage) and late L2 learners of Russian at the same proficiency levels. Regularity for Russian is understood as a continuous property of inflected words that range from regular to irregular rather than a dichotomous category. Given that even most irregular verbs use a regular set of inflections, there are practically no completely irregular verbs in Russian,¹ and verbs can be considered more or less regular depending on their morphological complexity. The latter refers to the degree and predictability of the allomorphy involved in different conjugational patterns. The article reports the results of two experiments—a verb generation task and a lexical decision task (LDT) with priming—and seeks answers to the following questions:
What are the differences between early (heritage) and late L2 morphological processing?

How is L2 processing of inflected word forms affected by regularity, morphological complexity, and token and type frequency?

First and Second Language Processing of Inflectional Morphology

This section will discuss the relevant hypotheses and findings on the processing of inflectional morphology by early and late L2 learners and the status of (de)composition in L2 processing of inflected word forms. For a more detailed discussion of the dual-system and the single-system approaches to morphological inflection in L1, the reader is referred to the Introduction to this issue by Gor.

With respect to first language (L1) processing, and largely based on English past tense inflection, the dual-system approach to inflectional morphology claims that two separate mechanisms operate in language processing: Regular word forms are computed online by symbolic rule application, whereas irregular word forms are stored undecomposed in associative memory and may be processed by associative patterning (Jaeger et al., 1996; Pinker, 1999; Pinker & Prince, 1994; Pinker & Ullman, 2002; Prasada & Pinker, 1993). The single-system approach, conversely, argues that there is only one mechanism—associative patterning based on phonological and semantic similarity—that operates in the processing of inflected word forms (Bybee, 1995; Elman et al., 1996; Rumelhart & McClelland, 1986; Seidenberg & Elman, 1999). Token (whole-word) frequency and phonological similarity effects have been used as measures of storage as opposed to computation. According to the dual-system approach, only irregular word forms will show token frequency effects, whereas according to the single-system approach, all of the inflected word forms, both regular and irregular, will show token frequency effects. As to type frequency, or the frequency of a particular inflectional pattern that can be represented as the size of a particular class of words using this pattern, only the single-system approach predicts its effects.

Several “hybrid” models find a middle ground between the radical versions of the dual-system and single-system approaches (Albright & Hayes, 2003; Baayen, Dijkstra, & Schreuder, 1997; Gor, 2003, 2004; Yang, 2002). The usage-based approach relying on the notion of schemas, which combine the properties of rules with input-driven factors such as input frequency, can also be categorized as a “hybrid” approach (Dabrowska, 2004, 2008; Langacker, 1987). The present study supports the rules and probabilities model (Gor, 2003, 2004), which claims that in inflectionally rich languages, morphological processing...
is rule-governed and at the same time is based on probabilities. The system of probabilities develops with linguistic experience and, in particular, is based on input frequencies. The rules and probabilities model applies to both L1 and L2 processing and predicts that the differences in L1 and L2 processing of inflection in the same language would be, in part, a reflection of the differences in native and nonnative input frequencies. It was formulated based on a series of studies comparing real and nonce verb generation by L1 and L2 speakers of Russian. These studies demonstrated a lack of categorical distinction between regular and irregular morphological processing for Russian, either as an L1 or L2 (Gor, 2003, 2004, 2007; Gor & Chernigovskaya, 2001, 2005). Instead, first, the Russian data highlighted the role of two factors in L1 and L2 morphological processing: (a) morphological complexity, or the degree and predictability of the allomorphy, and (b) type frequency, or the frequency of a declensional pattern (i.e., the size of a class of words with the same declensional paradigm). Second, it demonstrated a relationship between the amount and type of input, explicit and implicit, to late L2 learners and their preferences in the use of different morphological patterns (Gor & Long, 2009; Gor & Vdovina, 2010). These findings prompted the rules and probabilities model to claim that in L1 and L2 morphological processing, rules are applied with probabilities, which, in turn, depend on their input frequencies (Gor, 2003, 2004). Contrary to the blocking principle widely applied in formal linguistics, this model hypothesizes that highly frequent patterns or rules will be applied before and more quickly than low-frequency patterns and rules. The study of Russian verbal inflection highlights the role of (de)composition with the conjugational paradigm, including a small set of high-frequency standard and easily detachable inflections, and questions the possibility and cost-effectiveness of massive storage of all the inflected forms. In this sense, Russian verbal inflection is radically different from English irregular inflection, which has some clearly undecomposable past tense forms.

A testable prediction regarding early and late L2 processing has been proposed within the framework of the declarative/procedural model, which is a neurolinguistic extension of the dual-system approach (Ullman, 2001, 2004, 2006). According to Ullman (2001), late L2 processing of regular morphology relies on declarative memory and full-form storage rather than computation (decomposition), with a shift to the use of procedural memory and computation occurring only in highly proficient late L2 learners. Conversely, early L2 learners depend on procedural memory and computational mechanisms for regular (but not irregular) inflection, as do L1 speakers. This hypothesis was put forward mainly based on English, a language with sparse inflectional morphology. It should be noted that for English as the L1, a threshold frequency of six per million has
been established for whole-word storage of inflected words (Alegre & Gordon, 1999). Inflected words above this threshold show whole-word frequency effects. A similar relatively low threshold, though less precise and defined as a frequency range, was established for Swedish (Lehtonen et al., 2006).

This prediction of the declarative/procedural model has not received support from the studies of visual word recognition in Finnish, which is extremely rich in inflection. In a visual LDT, monolingual Finnish speakers processed polymorphemic Finnish words by decomposition in all of the frequency ranges except the very high-frequency range, where they relied on full-form representations (Soveri, Lehtonen, & Laine, 2007). Early Finnish-Swedish bilinguals did not make use of full-form representations in any frequency range (Lehtonen & Laine, 2003). Finnish presents an extreme case of rich inflection, with each Finnish noun theoretically having 2,000 inflected forms and 150 core inflected forms (Lehtonen et al., 2007, p. 124). It is to be expected that very few highly frequent inflected words would be stored undecomposed in native speakers and none at all in early bilinguals. Indeed, research on Swedish, a language with relatively limited inflectional morphology, revealed a different picture. A symmetrical study of Swedish visual word recognition by early Finnish-Swedish bilinguals and Swedish monolinguals showed similar patterns of morphological decomposition for low-frequency inflected nouns and full-form representations for medium- and high-frequency inflected nouns in both groups (Lehtonen et al., 2006). Two groups of Finnish-speaking late L2 learners of Swedish, who differ in proficiency, also used morphological decomposition, but only in the low-frequency range. They did, however, show evidence of full-form representations for medium- and high-frequency inflected nouns in both groups (Portin et al., 2007b). Therefore, there was no difference in the use of decomposition as opposed to whole-word processing depending on the word frequency among monolinguals, bilinguals, and late L2 learners of Swedish.

The most relevant study compared Swedish visual word recognition in two groups of L2 speakers: L1 speakers of Hungarian, an agglutinative language as is Finnish, and Chinese, an isolating language, which does not make use of inflectional morphology. The results indicate that Hungarian speakers applied morphological decomposition to medium- and low-frequency words, whereas Chinese speakers used full-form representations across all of the frequency ranges (Portin et al., 2007a). These differences are easily traceable to the participants’ L1 background. More interestingly, L1 Hungarian speakers did not rely on full-form representations for medium-frequency inflected Swedish nouns, whereas in another study, L1 Finnish speakers did (Portin et al., 2007b). This difference could not be associated with the L1 background, as speakers
both of Finnish and Hungarian, highly inflected languages, were expected to use predominantly decomposition for access and recognition of inflected words in the L2, as they do in the L1. Instead, the authors attributed the difference to the language learning background of each participant group. Whereas L1 Finnish speakers, who preferred whole-word access, received formal instruction in Swedish with intensive visual input, L1 Hungarian speakers in the study, who preferred decomposition, learned Swedish by immersion, with mostly oral input. The logic behind this conclusion reached by the authors is that Hungarian immersion-type learners had not had sufficient visual input in Swedish in order to form whole-word representations for inflected words, but Finnish formal learners had.

Overall, the results of the studies of the role of decomposition in inflected word recognition by native, early bilingual, and late L2 Finnish and Swedish speakers do not lend strong support to the declarative/procedural model (Ullman, 2001, 2004, 2006). Morphological richness in the L2, and also the L1, is the main determinant of the choice between full-form listing and decomposed representations, and it limits generalizability of the model’s predictions based on English. The declarative/procedural model predicts that late L2 learners first develop full-form representations and begin to rely on decomposition in word recognition only when they reach high proficiency levels, whereas early L2 learners prefer decomposition to full-form listing. In contrast, the data on Swedish word recognition by Finnish and Hungarian L1 speakers demonstrate that decomposition may developmentally precede full-form listing. It is plausible that full-form representations are indeed the first unanalyzed representations in the very beginning of L2 acquisition (and, possibly, L1 acquisition), but they seem to have a limited role in creative language use beyond recycling of unanalyzed chunks by novice L2 learners. Indeed, although it is uncontroversial that low-proficiency L2 learners experience problems with morphological processing, especially in the case of highly inflected languages, they do not store a sufficient number of inflected words to be able to rely on whole-word storage either. Such a late L2 learner profile is compatible with the claims of skill acquisition theory, which places emphasis on proceduralization of knowledge that is stretched over time (DeKeyser, 2007).

The role of L1 in the processing of regular and irregular L2 English inflected words was also demonstrated using a cross-modal repetition priming task with three groups of speakers (native English controls, and matched for proficiency L1 speakers of Serbian and Chinese) and two types of irregular verbs, with nested stem (drawn-DRAW) and change stem (ran-RUN), in addition to regular pairs (Basnight-Brown, Chen, Hue, Kostic, & Feldman, 2007).
Several outcomes of this study are relevant for the present one. First, by matching regular and irregular verbs on several parameters pertaining to semantic richness, the study showed no differences in the priming effects to regular and irregular verbs in native speakers of English. Second, L1 speakers of Serbian showed a priming effect for regular and only one type of irregular verbs, those with a nesting stem. Finally, the study hypothesizes that “graded magnitudes of inflectional facilitation will prevail as one contrasts irregular, semi-regular, and regular verbs” (Basnight-Brown et al., 2007, p. 78).

The declarative/procedural model predicts systematic differences between morphological processing in early and late L2 learners; however, it does not specify the ages corresponding to its definition of early and late learners. One can safely assume that the largest contrast between early and late learning is to be expected when early acquisition starts at birth and late acquisition starts after puberty, preferably, at college age. In order to test the claim that late L2 learners process inflected words differently from early learners, a direct comparison of early and late L2 morphological processing is needed. Although it is true that the early and late start, or age of acquisition (AoA), are usually confounded with other variables, such as the amount and type of input and formal learning, the most crucial variable—the proficiency level—can be controlled if one uses heritage (early interrupted) and late L2 learners at the same proficiency levels. The present study compares such groups of heritage and late L2 learners to detect possible differences in their processing of inflected words. Heritage speakers who begin learning Russian as the L1 at birth and switch to the L2 before puberty have the profile of early starters. In heritage speakers, the chronological sequence of the L1 and L2 becomes reversed in terms of proficiency, with the L2 becoming the dominant language. Due to lack of exposure to the L1 and attrition, they do not reach adult native proficiency in the L1, and often their L2 proficiency by far exceeds their L1 proficiency. They can be matched in L1 proficiency with late L2 learners, and the comparisons of these two populations make it possible to test the hypotheses about the differences in early and late L2 processing.

The comparison of Hungarian and Finnish L2 learners of Swedish (Portin et al., 2007a) emphasized the role of the type of learning background in shaping the processing mechanisms, with a formal classroom relying heavily on visual input and an immersion setting mostly providing auditory input. If the learning background does not match the testing modality, this can create disadvantages for L2 learners. Unlike late learners, early learners with little or no formal schooling may be at an advantage when processing auditory, but not visual input.
Heritage speakers’ acquisitional profile combining the elements of L1 and L2 acquisition has recently attracted much attention, but it is still not well documented. Overall, heritage speakers receive more native input, at least at the onset of learning, than late L2 learners. Heritage speakers mostly rely on implicit and oral input, whereas late L2 learners are heavily dependent on explicit and written input. A comparison of the characteristics of L1, L2, and heritage acquisition reveals that heritage acquisition shares with L1 acquisition early naturalistic exposure leading to early control of phonology, some vocabulary, and linguistic structures, and it shares with L2 acquisition most of its characteristics, pertaining to incomplete and variable learning (Montrul, 2008, 2009).

To summarize the above discussion, several factors influencing L2 morphological processing have been identified in the literature. These factors include the properties of L2 and L1 and the relationship between the two languages; the type of stimuli in terms of regularity and morphological complexity, learner characteristics, including age of acquisition (early or late); and the kind of exposure (formal or immersion-type). The latter two factors, in turn, determine whether the learners receive predominantly implicit or explicit visual or auditory input. The following section will focus specifically on the role of decomposition in lexical access. There are two main positions with regard to developmental tendencies in the use of (de)composition as opposed to full listing and access of the inflected word forms. According to Ullman (2001, 2004, 2006), early learners rely on procedural memory and use (de)composition, but late learners at the lower proficiency level (which is unspecified in the model) rely on declarative memory and whole-word storage. With increasing proficiency, late L2 learners’ reliance on procedural memory and (de)composition increases. Conversely, the studies of morphological decomposition in Swedish as an L2 (Portin et al., 2007a, 2007b) demonstrate that decomposition precedes full-form access in L2 speakers, with the latter typically observed in high-frequency inflected words.

However, the lack of decomposition in L2 processing of inflected word forms does not necessarily guarantee that a whole-word representation of the inflected word form is accessed in memory instead. The fact that Chinese L2 learners of Swedish did not rely on decomposition in lexical access of Swedish inflected words does not automatically imply that those L2 learners accessed stored representations of the inflected words. Given that their reaction times were much longer than those of L1 Hungarian speakers, it may be the case that they had deficits both in terms of decomposition and storage. What mechanism underlies their performance on a visual LDT? Two possibilities are worth
considering. First, a recent discovery in neurolinguistics has found support for the hypothesis that L1 decomposition and Gestalt semantic processing can be activated independently because they rely on independent paths in the brain—the dorsal pathway linked to phonological decomposition, and the ventral pathway linked to semantic processing (Hickock & Poeppel, 2004). It has been proposed that the dorsal path constitutes a decompositional stream also responsible for morphological inflection (Marslen-Wilson & Tyler, 2007). Because these two pathways can function in parallel and relatively independently of each other—or, alternatively, only one of the two can be activated depending on a set of conditions—they seem to provide a neural substrate for the dual-route model of L1 morphological processing (Baayen et al., 1997). The dual-route model maintains that two competing routes—decomposition and full-form access in associative memory—are activated in parallel, where the fastest is the observable method. Independent evidence of automatic morphological decomposition in L1 obtained in experiments using decomposable nonce words with easily detachable inflections is linked to the dorsal pathway (Marslen-Wilson & Tyler, 2007). It is possible that L2 speakers use the ventral stream and thus avoid decomposition more than L1 speakers.

The second possibility one should consider is the extension of the shallow-structure hypothesis formulated primarily for L2 processing of syntax and morphosyntax (Clahsen & Felser, 2006) to inflectional morphology. In its original formulation, the shallow-structure hypothesis argues that in L2 learners, syntactic parsing is not supported to the extent it is supported in L1 speakers, and as a result, L2 sentence processing is based on lexical and semantic cues rather than syntactic cues. One can see that the two possibilities are not in conflict with each other and may be pointing to the same underlying mechanisms.

**Russian Verb Conjugation**

The present article presents the results of two experiments on generation and recognition of Russian inflected verbs. Russian, a Slavic language, has rich inflectional morphology, allowing the researchers to control and manipulate verb characteristics (Spencer, 1999; Townsend, 1975). Russian has 11 verb classes ranging in morphological complexity and size (type frequency). Morphological complexity refers to the morphological and morphonological processes taking place at the juncture of the stem and the inflection. These processes range from automatic consonant and vowel truncation, that apply to any verb, to consonant mutations, suffix alternations, vowel deletions, and so forth (see Table 1).
Table 1 Verbs used in the experiments

<table>
<thead>
<tr>
<th>Verb class (suffix)</th>
<th>Stem and gloss</th>
<th>Morphological process(es) in infinitives</th>
<th>Morphological process(es) in first-person singular</th>
<th>Frequency</th>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>-aj-</td>
<td>rabot-aj- “work”</td>
<td>rabota-t’ Automatic consonant truncation</td>
<td>rabotaj-u</td>
<td>High</td>
<td>Productive</td>
</tr>
<tr>
<td>-a-</td>
<td>pis-a- “write”</td>
<td>pisa-t’</td>
<td>pish-u Automatic vowel truncation Consonant mutation</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>-i-</td>
<td>xod-i- “go”</td>
<td>xodi-t’</td>
<td>xozh-u Automatic vowel truncation Consonant mutation</td>
<td>High</td>
<td>Productive</td>
</tr>
<tr>
<td>-ova-</td>
<td>ris-ova- “draw”</td>
<td>risova-t’</td>
<td>risuj-u Suffix alteration Automatic vowel truncation Consonant mutation</td>
<td>High</td>
<td>Productive</td>
</tr>
<tr>
<td>-e-</td>
<td>sid-e- “sit”</td>
<td>side-t’</td>
<td>sizh-u Automatic vowel truncation Consonant mutation</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>-ø-</td>
<td>moj-ø- “wash”</td>
<td>my-t’ Automatic consonant truncation Vowel alternation</td>
<td>moj-u</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>kla-ø- “put”</td>
<td>kla-st’ Automatic consonant truncation Special infinitive</td>
<td>klad-u</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>zh/g-ø- “burn”</td>
<td>zhe-ch’ Non-syllabic stem/fleeting vowel Automatic consonant truncation</td>
<td>zhg-u</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsyllabic</td>
<td>z/v-a- “call”</td>
<td>zva-t’ Automatic consonant truncation Special infinitive</td>
<td>zov-u Automatic vowel truncation Fleeting vowel</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>
that apply to verbs in large and also very small classes. Such morphological process, in turn, may apply to many or few forms in the paradigm. Russian verbs consist of a stem and an easily decomposable inflection. The stem comprises a root and a suffix, or verbal classifier, that determines all of the parameters of the conjugational paradigm: conjugation type, first or second, which is defined by the thematic vowel, e or i, consonant mutations, suffix alternations, vowel alternations, special infinitive inflections, and all other idiosyncratic features.7 The number of bare stems (simple, unprefixed verbs) per class varies from over 11,000 to 3. Importantly, as first discovered by Jakobson (1948), whether large or small, all the verb classes show rule-governed allomorphy. The 11th class, with a zero suffix and less than 100 stems, includes several small subclasses with irregularities captured by minor rules. This class can be compared to English irregular verbs forming small neighborhoods based on similar morphonological processes.8 Additionally, approximately 20 stems have unpredictable features in their conjugation, sometimes involving only one verb form, and are thus considered irregular (Townsend, 1975).

Russian verbs have two tenses: the non-past-tense (present or future, depending on the aspect of the stem) and the past tense. The non-past-tense includes six forms: three marked for person in the singular and three in the plural. The past tense includes four forms: three marked for gender and one plural form. The one-stem verb system introduced by Jakobson (1948) makes it possible to generate all of the forms in the paradigm by the application of (a) the automatic truncation rule, according to which the first of the two consonants or two vowels at the juncture of the stem and the ending is truncated; and (b) the rules specific for a particular class. However, due to this truncation rule, the stem with the verbal classifier cannot be always derived from the infinitive, as illustrated in (1) and (3). The infinitives of the verbs “read” and “write” look similar due to the truncation of j in “read,” both ending in -at’, but the underlying basic stems and conjugational patterns are different. Note simple addition of the ending to the stem in (2) as opposed to vowel truncation and consonant mutation in (4).

(1) chit-aj- + t’ = chitat’ “read” (automatic truncation of the “j”)
(2) chit-aj- + u + chitaju “I read” (simple addition at the juncture of the stem and the ending)
(3) pis-a- + t’ = pisat’ “write” (simple addition at the juncture of the stem and the ending)
(4) pis-a- + u = pishu “I write” (automatic truncation of the “a” and consonant mutation)
This fact has two implications. First, lexical entries in the mental lexicon need to be represented with a basic stem or some kind of tagging and, second, stem recovery for novel verbs can be performed based on morphological cues and/or probabilities, with a greater or lesser degree of guessing, depending on the verb class.

The six verb classes that were used in the two experiments will be briefly introduced next (see also Table 1 for a list of verb classes and subclasses used in both experiments, with the main morphological processes occurring in their conjugation). They range in regularity, productivity, type frequency, and the presence of the cues, making it possible to recover the stem from the infinitive. The high-type-frequency regular productive default -aj- class has only an automatic truncation rule, but its infinitive ends in the rhyme -at’, as does the infinitive for the small unproductive -a- class with consonant mutations. Thus, a novel infinitive -at’ will be conjugated based on probabilities, with the preference expected to be given to the -aj- pattern. The high-type-frequency productive -i- class is much more complex than the -aj- class. It has the same conjugational pattern as the small unproductive -e- class and the same level of morphonological complexity as the -a- class. The infinitives of the -i- class ending in -it’ have few enemies in other verb classes, but the infinitives of the -e- class compete with the small but productive -ej- class because both end in -et’. Based on probabilities, the infinitives ending in -it’ should follow the -i- pattern, whereas the infinitives in -et’ can follow either pattern. The large productive -ova- class has a rare feature—suffix alternation—but the -ova- suffix preserved in the infinitive serves as a strong cue to the conjugational pattern. The priming experiment uses a category of verbs labeled as “irregular,” which in fact includes mostly verbs from the zero-suffixed class with irregularities, or minor rules, several verbs from the “true” irregular list, and nonsyllabic -a- class verbs with fleeting vowels. The most pertinent feature of some of the “irregular” zero-suffixed verbs are special infinitive inflections; although rare, they serve as unambiguous cues to the conjugational pattern. Allomorphic changes between infinitives and finite nonpast forms in “irregular” verbs may involve consonant and vowel change or truncation and fleeting vowels.

Based on the earlier data on L1 and L2 processing of Russian verbal morphology, it was hypothesized that the verbal system operating in the mind of speakers/hearers is a psycholinguistic adaptation of the one-stem verb system (Gor, 2003). Different infinitive rhymes, in addition to being tagged for the conjugational pattern and/or connected to a stem-based representation encoding all of the properties of the conjugational pattern, are probabilistically associated with two main conjugational patterns—the “vowel + j” pattern (as in -aj-)
and the “vowel + ø” pattern (as in -a-)—plus several smaller ones (Gor, 2003, 2004). To summarize, the Russian verb system makes it possible to separate morphological complexity from type frequency. For example, both the regular default -ar- class and the much less regular -i- class have high type frequency, whereas the -a- class comparable in complexity with the -i- is small and unproductive.

Experiment 1: Real and Nonce Verb Generation

Background and Rationale
Previous research on Russian real and nonce verb generation by adult L1 and L2 speakers has used the same elicitation paradigm as in the current experiment but different stimulus material. It has demonstrated that the choice of the conjugational pattern for novel verbs is influenced by complexity of the paradigm, probabilities based on type frequencies of different conjugational patterns, and availability of morphological cues in the provided verb form. Beginning L2 learners lagged behind native speakers in correct stem and accuracy rates, especially on the verb classes with low type frequency and complex inflectional paradigms (Gor & Chernigovskaya, 2001, 2005). Advanced L2 learners, who had more exposure but less explicit instruction in verb conjugation, outperformed beginning L2 learners with limited exposure but intensive explicit training in verb conjugation, on the high-type-frequency productive regular default -ar- pattern. However, this was not the case on the lower type frequency less regular -ova- and -i- patterns (Gor & Long, 2009).

The goal of the present experiment was (a) to document the impact of structural and input frequency factors on highly proficient L2 morphological processing and (b) to compare the internalized morphological systems underlying familiar and novel (nonce) verb conjugation in “true” late L2 learners and early interrupted heritage learners of Russian at the same proficiency levels and to attempt to connect the differences in their performance with their language learning backgrounds.

The design of the study required the use of both real and nonce verbs because real and nonce verb generation depends on different underlying mechanisms. Real verb generation tests whether the lexical entry with its conjugational pattern are known to nonnative speakers. Nonce verb generation tests the ability of nonnative speakers to recover the conjugational pattern from the infinitive based on the available morphological cues and probabilities and to apply it accurately. Thus, nonce verb generation is a test of the knowledge of verb
conjugation and of the probabilities associated with a particular infinitive rhyme, not of the conjugational patterns of familiar verbs.

It was hypothesized that early interrupted exposure with little or no formal training creates a disadvantage for heritage speakers in the application of complex inflectional rules in novel verbs. It predicted that late formal L2 learners would outperform heritage speakers in nonce verb generation, the use of less regular nondefault patterns, and morphological cues. Heritage speakers were expected to show an advantage in relying on probabilities (in the absence of cues) and applying the most regular and high-frequency -aj- pattern by default.

Therefore, the study tested the following predictions:

1. Late L2 learners will outperform heritage speakers in real verb generation, but not nonce verb generation.
2. Late L2 learners will be more efficient in the use of morphological cues to the conjugational pattern, whereas heritage speakers will be better in the use of statistical probabilities (in the absence of cues) and the default conjugational pattern.

Although the application of the regular high-frequency productive default -aj- pattern should not itself present any difficulties for either heritage or L2 learners, the choice between the -aj- pattern and the low-frequency -a- pattern with complex allomorphy for -at’ rhymes is mainly guided by implicit knowledge of statistical probabilities, thus giving a possible advantage to heritage speakers. L2 learners were expected to outperform heritage speakers on the -ova- and -i- patterns. Both patterns are high frequency and productive, but they require the efficient use of morphological cues present in the infinitive and the involvement of complex allomorphy.

Participants
Seventy paid volunteers took part in the experiment: 36 adult American learners of Russian, 24 heritage speakers of Russian living in the United States, and 10 adult native Russian controls. The age of L2 learners was 21–56 years ($M = 32.1$); for heritage learners, it was 18–51 years ($M = 22.5$), and for native speakers, it was 20–54 years ($M = 36.7$). There were 31 male and 39 female participants. Nonnative participants were pretested using the ILR oral proficiency interview format, and the two nonnative groups corresponding in proficiency levels were formed. Both groups ranged from 1 to 4 on the ILR scale, with most participants falling between ILR levels 2 to 3, which corresponds to Advanced and Superior oral proficiency on the ACTFL scale. For statistical analyses, both the L2 and heritage groups were divided into two
subgroups, corresponding to “high” (ILR 2+ and above) and “low” (ILR 2 and below) oral proficiency. The mean age of English onset for heritage learners was 6.9 years (range: 0 and 14 years), whereas for L2 learners, the average age of first exposure to Russian in the classroom was 18.4 years (range: 13 and 27 years). Thus, L2 learners started learning Russian after puberty, mostly as young adults, whereas heritage speakers were exposed to Russian at home since birth. Heritage speakers switched to English at various ages, and at the moment of testing, English was their dominant language. None of them lived in a Russian-speaking environment after puberty, and although all could read in Russian, they had little or no formal elementary schooling in Russian. The majority of heritage speakers (20 out of 24 participants) did not have any further formal training in Russian, with the exception of 4 participants who took Russian language courses as a part of high school or college curriculum. The amount of formal exposure to Russian of those four participants was, on average, 3 years, ranging from 2 to 6 years. Thus, our two groups of nonnative speakers were at the same oral proficiency levels in Russian; however, “true” L2 learners were late starters, whereas heritage speakers were early starters, with Russian being their L1.

Materials and Method
The experiment used five verb classes (-aj-, -a-, -e-, -i-, and -ova-), two frequency ranges, and two sets of verbs: real and nonce, with five verbs in each category, 100 verbs total (see Table 1 for details on the conjugational patterns). The selected verb classes included three high-frequency productive classes ranging in morphological complexity (-aj-, -i-, and -ova-) and three verb classes ranging in type frequency and productivity and of comparable complexity (-a-, -e-, and -i-). This design made it possible to separate morphological complexity and type frequency. The nonce verbs were created by manipulating the initial segment, usually the initial consonant or consonant cluster of the real verbs used in the experiment, and were categorized as high and low frequency based on the real verb prototypes. For example, the nonce verb “vremEt’” is based on the real verb “gremEt’” (“thunder”) belonging to the -e- class, but its infinitive could also be interpreted as belonging to the -ej- class. Given the fact that the verb stem (and therefore the conjugational pattern) could not always be unambiguously retrieved from the provided nonce infinitives, the choice of the conjugational pattern by the participants for most classes (except -ova-) was guided by the knowledge of their probabilities (see Table 2 for the information on the testing material). The frequency ranges chosen for this experiment (Zasorina, 1977) although labeled as high and low
### Table 2 Verbs used in Experiment 1

<table>
<thead>
<tr>
<th>Verb class</th>
<th>-aj-</th>
<th>-i-</th>
<th>-ova-</th>
<th>-a-</th>
<th>-e-</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type frequency</strong></td>
<td>11,735</td>
<td>7,174</td>
<td>2,815</td>
<td>842</td>
<td>326</td>
</tr>
<tr>
<td><strong>Token (lemma) frequency category</strong></td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Average lemma frequency</strong></td>
<td>14.6</td>
<td>Less than 1 per million</td>
<td>15.4</td>
<td>Less than 1 per million</td>
<td>16.6</td>
</tr>
<tr>
<td><strong>Examples of real verbs</strong></td>
<td>golodat’ ‘starve’</td>
<td>chirikat’ ‘chirp’</td>
<td>toropit’ ‘hurry someone’</td>
<td>lebezit’ ‘flatter’</td>
<td>vorovat’ ‘steal’</td>
</tr>
<tr>
<td><strong>Examples of nonce verbs</strong></td>
<td>tolodat’</td>
<td>virikat’</td>
<td>goropit’</td>
<td>shebezit’</td>
<td>morovat’</td>
</tr>
</tbody>
</table>

*Note.* There were five real and nonce verbs in each of the verb classes and frequency ranges. Type frequencies are based on Zaliznjak (1980).
in fact represent the medium- and low-frequency ranges. Based on the established frequency threshold on whole-word storage of inflected word forms in English (six per million) and a similar one in Swedish (Alegre & Gordon, 1999; Lehtonen et al., 2006) and on the fact that Russian is a highly inflected language, it is safe to assume that most verbs used in the experiment do not have whole-word representations of their inflected forms, even in a native lexicon. Moreover, low-frequency lexical items themselves may not be familiar to all of the nonnative participants. All of the verbs were unprefixed, imperfective, and their length was controlled at seven to nine letters and two to three syllables.

The stimulus material was recorded by a female speaker. Testing was computer-based, with each subject tested individually on Dell Latitude/D820 computers with headsets and game pads in a quiet room. The sound recordings used in the study were digitized and processed using Praat software, and all of the experiments were programmed in DMDX. The statistical analyses of the obtained results were performed with SAS. The verbs were presented auditorily twice in infinitive forms, through the headsets, and participants were asked to generate first the first-person singular and then the second-person singular non-past-tense, with each subject producing 200 responses, two verb forms per each stimulus infinitive. The need for two forms was dictated by the fact that different forms in the paradigm contain different information about the inflectional rules applied by the speaker. The main test was preceded by two practice trials. The responses were digitally recorded and then transcribed and coded. The analyses of accuracy are reported in the next section. For the nonce verbs, the accuracy score refers to the responses that matched the conjugational pattern of the prototype.

Results
The accuracy means with standard deviations are provided in Table 3. As a preliminary analysis, the by-subject ANOVA was performed on the accuracy data for all three groups of participants. Their purpose was to compare the two learner groups to the native control group. However, only the two-group analysis could include the ILR proficiency variable with two levels: high and low. The ILR variable was inapplicable to native speakers; therefore, three groups and ILR were impossible to combine. The preliminary ANOVA had a two-way design with the Group (Native, L2, and Heritage) and Verb Class (-aj-, -a-, -e-, -i-, and -ova-) conditions and showed a significant main effect for Verb Class, \(F(4, 268) = 20.52, p < .001\), and Group, \(F(1, 67) = 6.39, p < .01\). According to Tukey’s pairwise comparisons, the Native group had a considerably higher accuracy rate than either of the learner groups, contributing
Table 3  Accuracy means for Experiment 1: Heritage, L2, and Native groups

<table>
<thead>
<tr>
<th>Type of stimuli and verb classes</th>
<th>High frequency</th>
<th>Low frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heritage M SD</td>
<td>L2 M SD</td>
</tr>
<tr>
<td></td>
<td>Heritage M SD</td>
<td>L2 M SD</td>
</tr>
<tr>
<td>Real verbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-a-</td>
<td>0.60 0.17 0.35</td>
<td>0.12 0.88 0.08</td>
</tr>
<tr>
<td>-aj-</td>
<td>0.92 0.12 0.85</td>
<td>0.06 0.90 0.10</td>
</tr>
<tr>
<td>-e-</td>
<td>0.85 0.09 0.62</td>
<td>0.15 0.93 0.08</td>
</tr>
<tr>
<td>-i-</td>
<td>0.78 0.11 0.79</td>
<td>0.09 0.91 0.07</td>
</tr>
<tr>
<td>-ova-</td>
<td>0.85 0.11 0.94</td>
<td>0.07 0.97 0.06</td>
</tr>
<tr>
<td>Nonce verbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-a-</td>
<td>0.29 0.17 0.19</td>
<td>0.11 0.56 0.32</td>
</tr>
<tr>
<td>-aj-</td>
<td>0.58 0.10 0.68</td>
<td>0.09 0.68 0.14</td>
</tr>
<tr>
<td>-e-</td>
<td>0.51 0.19 0.37</td>
<td>0.12 0.73 0.13</td>
</tr>
<tr>
<td>-i-</td>
<td>0.65 0.14 0.74</td>
<td>0.13 0.70 0.20</td>
</tr>
<tr>
<td>-ova-</td>
<td>0.49 0.16 0.73</td>
<td>0.15 0.84 0.06</td>
</tr>
</tbody>
</table>

to the Group effect ($p < .01$ for the contrast between Native group and both the L2 and Heritage groups). The interaction between Group and Verb Class was also significant, $F(4, 268) = 10.00, p < .001$. This result indicates that the participants in different groups experienced different levels of difficulty with the five verb classes, as reflected in their accuracy scores. There was, however, a general trend, as demonstrated by Tukey’s post hoc pairwise comparison of the Verb Classes that revealed that the -a- verbs had the lowest accuracy rate and were significantly different from the other four classes of verbs ($p < .001$ for all contrasts with the -a- verbs). Although the -e- verbs presented a slightly lesser challenge to the participants, they were still significantly harder than the -aj- and -ova- verbs ($p < .01$ for both contrasts). The -i- verbs were not more difficult than the -e- verbs ($p = .117$) or the -aj- and -ova- verbs ($p = .807$ and $p = .740$, respectively). The significance of these contrasts within each learner group will be discussed in more detail in the two-group analysis below.

A five-way ANOVA with the independent variables of Group (L2 and Heritage), Proficiency (high and low), Stimulus Type (real or nonce verb), Verb Class (-aj-, -a-, -e-, -i-, and -ova-), and Frequency (high and low) was performed on the accuracy data with two learner groups—L2 and Heritage. The two-group ANOVA produced significant Stimulus Type, $F(1, 54) = 100.65, p < .001$, Verb Class, $F(4, 216) = 35.36, p < .001$, Frequency, $F(1, 54) = 106.61,
The results show a significant main effect of Verb Class, $F(4, 216) = 12.80, p < .001$, and a significant interaction between Group and Verb Class, $F(4, 216) = 12.80, p < .001$. The Group effect did not reach significance, $F(1, 54) = .07, p = .799$. Although the L2 and Heritage groups did not show a significant main effect, the two-way interactions between Group and Verb Class, $F(1, 54) = 21.50, p < .001$, and Group and Stimulus Type, $F(1, 54) = 12.20, p < .001$, reflect significant differences in how these two groups treated individual verb classes and real and nonce verb types. The comparison of the accuracy means (see Table 3) indicates that the L2 group outperformed the Heritage group on nonce verbs. There was also a significant interaction between Frequency and Stimulus Type, $F(1, 54) = 82.76, p < .001$, Proficiency and Group, $F(1, 54) = 4.33, p < .05$, and ILR and Stimulus Type, $F(1, 54) = 7.03, p < .05$. Here and in the following, all of the significant two-way interactions are reported in the main text, with significant three-way interactions reported in the notes.\(^{16}\)

Tukey’s test of pairwise comparisons indicates that heritage speakers outperformed L2 learners on the -aj-, -a-, and -e- classes (significant at $\alpha = .05$) across different stimulus types and frequency levels. However, L2 learners performed significantly better on the -ova- and low-frequency nonce -i- verbs than their heritage counterparts.

**Discussion**

Verb Class and Stimulus Type (real or nonce verb infinitive) were significant factors in verb generation both in three-group and two-group analyses. Additionally, frequency was significant in a two-group analysis. Thus, high-frequency real verbs were predictably produced with higher accuracy rates than low-frequency verbs, and nonce verbs were more difficult than real verbs. All of the groups showed the highest accuracy on the high-frequency regular productive default -aj- pattern and the lowest accuracy on the low-frequency unproductive -a- pattern with complex allomorphy, also competing with the -aj- pattern in nonce verbs with unrecoverable conjugational patterns ending in -at’.

Although the general tendencies in responses were similar across the three groups, both the L2 and Heritage groups lagged behind the Native group in their accuracy rates in real and nonce verb generation. At the same time, there were significant differences between the results obtained for the two learner groups. Heritage speakers steadily outperformed L2 learners in accuracy on the -aj- and -a- classes, which for novel verbs involves implicit knowledge of probabilities that develops under the influence of native input. They were also consistently more accurate on the small, less regular -e- class belonging to the “vowel + ø” pattern whose infinitive competes with the -ej- class belonging to
the regular “vowel + j” pattern. Both classes are poorly represented in the input, and L2 learners with reduced input compared to heritage speakers were more willing to overgeneralize the “vowel + j” pattern to both the -a- and -e- verbs, a phenomenon termed the Free-Rider effect (Yang, 2002). At the same time, L2 learners were better on the -ova- class that requires the use of a morphological cue for novel verbs. Remarkably, overall, heritage speakers’ accuracy rates were consistently higher than L2 learners’ rates only on real verbs, an indication that heritage speakers were more dependent on stored representations. It should be noted that, developmentally, the high-frequency regular default -aj- class is the first one to be acquired by Russian L1 children, with the other classes used in Experiment 1 acquired later (Gor & Chernigovskaya, 2003). The -aj- class has been shown to be overgeneralized to the other classes in verb generation by younger Russian L1 children at age 4 with normal linguistic development, L1 children with linguistic impairments and by low-proficiency L2 learners of Russian (cf. Gor & Chernigovskaya, 2003). The -ova- class, in addition to being acquired late in the L1, presents great difficulties to lower proficiency L2 learners, especially, with limited formal instruction. Apparently, this is due to the fact that it involves the use of a morphological cue and a complex morphological rule: suffix alternation (Gor & Chernigovskaya, 2003; Gor & Long, 2009).

There are several differences between the learning experiences of the L2 and Heritage participants, and this study was not designed to disentangle them. However, it can attempt to tentatively associate the obtained results with the learning backgrounds, such as the differences in the timing of the onset of learning, and the timing and amount of native implicit input and explicit training in verb conjugation they had received. Thus, early heritage learners, who received abundant native input at the onset of learning, tend to rely on the default conjugational pattern, their knowledge of statistical probabilities, and stored representations. Late formal L2 learners who were exposed to explicit conjugational rules, but not rich implicit native input, at least at the onset of learning, outperformed heritage learners on the use of complex morphological rules, especially in novel verbs.

Therefore, one can conclude that Experiment 1 supported the predictions and documented the response patterns in real verb generation and generalization rates in nonce verb generation that can be associated with morphological complexity, morphological cues to the conjugational pattern as structural aspects of verbal inflection, and type and token (lemma) frequency in verb generation. The differences between L2 and heritage results indicate that overall late formal L2 learners outperformed heritage speakers at the same proficiency levels on
nonce verb generation, especially on the high-frequency productive patterns. In other words, late formal learners were better at applying the conjugational patterns to novel verbs, whereas heritage speakers were more dependent on stored representations of familiar verbs. Heritage speakers were better than L2 learners at the use of the regular default -aj- and the -a- patterns, with the choice between the two for novel verbs guided by the knowledge of statistical probabilities and the tendency to rely on the default pattern. Conversely, L2 learners showed a consistent advantage on the -ova- verbs, which depends on the use of a morphological cue and a complex morphological rule (suffix alternation). Taken together, these results (a) support the role of early implicit native input in shaping nativelike developmental tendencies and probabilistic mechanisms in early starters and (b) the role of formal instruction in developing structural knowledge of inflectional rules in late formal L2 learners. The differences between highly proficient early and late starters in the study do not show an advantage in morphological rule application to novel verbs in early starters; rather, they support the reliance of early starters on lexical storage.\(^{17}\)

**Experiment 2: Auditory Lexical Decision Task With Priming**

**Background and Rationale**

Experiment 2 investigated the perception of inflected Russian verbs in an auditory LDT with priming.\(^{18}\) It explored the facilitatory morphological priming effects, which were shown for English as the L1 but which remain a largely unresolved issue (a) for languages with rich inflection and no categorical distinction between regular and irregular morphological processing and (b) for L2 learners of those languages. Because, to the best of our knowledge, there has been no research on morphological priming effects in Russian, a Slavic language with a rich inflectional system and easily detachable endings even in irregular verb paradigms, either as an L1 or L2, several relevant articles on priming in the Romance languages Italian, Spanish, and Catalan will be briefly discussed next.\(^{19}\)

A cross-modal immediate repetition priming study tested whether Italian verbs would show the same categorical distinction between regular and irregular inflection as in English (Orsolini & Marslen-Wilson, 1997). In particular, English regular, but not irregular, inflected verbs primed their base form (infinitive) (Marslen-Wilson, Hare, & Older, 1993). For Italian, however, it was found that both regular and irregular inflected forms produced a similar priming effect, a result that challenges the dual-system approach and suggests that because all Italian verb forms are inflected, decomposition, rather than
whole-word processing, takes place even for the forms with irregularities in the stem (complex stem allomorphy). This universal decomposition mechanism provides the basis for prime-target mappings and leads to a priming effect. Although no statistically significant differences were found between the two regular and two irregular conditions, the irregular condition, which did not involve any mapping difficulties due to stem allomorphy, produced a greater priming effect than the irregular condition, which used different allomorphs and complex mapping (Orsolini & Marslen-Wilson, 1997).

A delayed visual repetition priming study with Spanish monolinguals, which targeted Spanish regular and irregular inflected verbs (Rodriguez-Fornells et al., 2002), was a follow-up on a similar study demonstrating different event-related potential (ERP) patterns for regularly and irregularly inflected past tense primes in English (Münte, Say, Clahsen, Schiltz, & Kutas, 1999). Although there were no statistically significant differences in the observed priming effects between the matched conditions using inflected primes with nonalternated (regular) and alternated (irregular, or, more exactly, semiregular) stems, they elicited different brain potentials. An ERP study with two groups of early bilingual speakers—one with Spanish as L1 and Catalan as L2 and the other with Catalan as the L1 and Spanish as the L2—and three types of inflected Spanish verbs—regular, semiregular, and irregular (De Diego Balaguer et al., 2005)—demonstrated the same effect in Spanish L1 speakers as the study by Rodriguez-Fornells and collaborators (2002). Native speakers showed an attenuated N400 effect signaling that the target was considered “old” when it was preceded by a matched prime earlier in the sequence for regular verbs, but not semiregular verbs, mostly alternated stems with diphthongs. Conversely, L1 speakers of Catalan showed an attenuated N400 effect for regular and idiosyncratic (“true” irregular) verbs. These results indicate differences in native and early L2 morphological processing.

Experiment 2 explored late L2 and heritage processing of Russian inflectional morphology in three types of verbs: regular (-aj-), semiregular (-i-), and irregular. The frequency of all of the verb types was closely matched for both frequency ranges (see details below); consequently, the observed latencies in different groups and in response to verbs of different types—primed and unprimed—were expected to reflect morphological processing per se. Experiment 2 tested the following predictions:

1. There will be differences in response times (RTs) to regular, semiregular, and irregular verbs.
2. The Heritage and L2 groups will differ in their RTs to the three verb types.
3. There will be priming effects in response to all of the verb types.
4. The size of the priming effects will depend on the verb type.
5. The size of the priming effects will depend on the proficiency level of the learners.
6. The size of the priming effects will reflect ease of decomposition and mappings. In particular, the latencies in the unmatched condition will depend on ease of decomposition and type frequency of inflections. In the matched condition, the latencies will be further affected by the complexity of mapping between the prime and the target.

Participants
The same paid group of 70 participants that took part in Experiment 1 also participated in Experiment 2. The participants were assigned to one of the two versions of the priming task after their oral proficiency rating had been established; this made it possible to balance the proficiency levels in nonnative participants who took each version of the task.

Materials and Method
The priming experiment used three types of verbs, corresponding to the regular, semiregular, and irregular categories of Spanish verbs used in a study of Catalan-Spanish bilinguals (De Diego Balaguer et al., 2005): the regular high-frequency default -aj- class, the semiregular high-frequency productive -i- class with complex allomorphy (i.e., consonant mutations in the first-person singular), and the irregular type, including several “true” irregular verbs with idiosyncratic allomorphy and verbs from small subclasses, with three to seven stems sharing the same minor rules in their conjugational pattern (see Table 1 for examples of the verbs of each type). Almost half of the infinitives in the irregular type have special endings, which is extremely rare in Russian. Due to their morphological structure, the infinitives of irregular verbs were shorter in length (one to two syllables), with the other two types matched in length (two to four syllables). All of the verbs were unprefixed imperfectives. Twenty verbs in each of the three types were used in two closely matched lemma (cumulative) frequency ranges: the high-frequency range with log frequency of 1.25–2.25 (18–222 per million) and the low-frequency range with log frequency of 0–1.0 (1–11 per million) in Sharoff’s Corpus (Russian Internet Corpus, approximately 90 million words at the time of use). The matched primes were in the first-person singular non-past-tense, and the targets were the infinitives of the same verbs. In the unmatched condition, the same targets were used with the first-person singular of different verbs from the same frequency range.
as unmatched primes. For example, the matched pair *noshu*-NOSIT' (I carry-carry) corresponds to the unmatched pair *sluzhu*-NOSIT' (I serve-carry). The matched and unmatched pairs were counterbalanced in two versions of the task, so that each individual participant heard the target only once, with half of the targets primed and half unprimed (preceded by an unmatched prime). Thus, the number of verb pairs was 80 per each of the three verb types (20 matched high frequency, 20 matched low frequency, 20 unmatched high frequency, and 20 unmatched low frequency), with the total of 240. Each participant heard only 120 pairs—half matched and half unmatched—with an additional 40 pairs of matched and 40 pairs unmatched semantic primes and targets, and 40 pairs of matched and 40 pairs unmatched phonological primes and targets that served as fillers. An equal number of pairs with real word primes and nonce word targets were created for each priming condition (120 pairs for morphological, 40 pairs for semantic, and 40 pairs for phonological priming). Overall, 400 word pairs were used in each of the two counterbalanced versions of the task. Both the prime and the target were presented aurally through the headsets, with an interstimulus interval of 320 ms. The RTs were timed from the beginning of the target stimulus. Participants were instructed to press one of the two buttons depending on whether the second word in each pair was a word or a nonword. There were practice trials preceding the main experiment. The trials were randomized, with all of the participants receiving the same order. As in Experiment 1, the testing in Experiment 2 was computer-based. Each participant was tested individually in a quiet room on Dell Latitude/D820 computers with headsets and game pads. The sound recordings by a male speaker were digitized and processed using Praat software, and the experiments were programmed in DMDX. The statistical analyses of the results were performed with SAS.

Results
Two parameters of participants’ responses—RTs and accuracy—were analyzed. Whereas accuracy is a less important behavioral measure in priming experiments with native speakers, it becomes a more meaningful measure in nonnative processing, because accuracy levels indicate whether a certain frequency range is more or less familiar to nonnative speakers. RTs and, in particular, the priming effects, or the difference between RTs to unprimed and primed targets, remain the main measure. All RT results obtained from the target items scored “incorrect” were eliminated from the RT analysis, along with responses to nonword stimuli. Individual RTs 300 ms below or two standard deviations above the mean RT were eliminated as outliers. The data from two subjects were excluded because the data were missing in one of the conditions. In
addition, the data points from eight items were removed because of the low accuracy rate. This resulted in the elimination of 5.1% of the individual RTs for items that were scored as correct and had a target that was a real word in Russian. As in Experiment 1, the exploratory RT and accuracy analyses were conducted for all three participant groups: Heritage, L2, and Native. Next, the two learner groups—Heritage and L2—were further subdivided into high- and low-proficiency groups based on their ILR scores. The Native group had to be excluded from those main analyses.

The by-subject and by-item repeated measures ANOVAs were conducted for RTs and accuracy in three groups and included only two variables of interest—Group (Heritage, L2, and Native) and Verb Type (-aj-, -i-, and irreg). For RTs, a significant main effect for Group, $F_1(1, 67) = 5.90, p < .01$; $F_2(1, 137) = 295.85, p < .001$, was observed. The main effect for Verb Type was significant in the by-subject analysis, but not the by-item analysis, $F_1(2, 134) = 8.36, p < .001$; $F_2(1, 137) = 1.33, p = .267$. A two-way Group × Verb Type interaction was also significant, $F_1 (2, 134) = 4.19, p < .01$; $F_2(2, 274) = 2.36, p < .05$. Tukey’s post hoc pairwise comparison showed that the main effect for Group is triggered by the difference in performance between the Heritage and L2 groups, which was statistically significant ($p < .01$), whereas the Native group did not differ from either of the nonnative groups ($p = 0.101$ for Heritage and $p = 0.918$ for L2). Thus, the Heritage group was the fastest and outperformed both the Native and L2 groups, although only the difference with the L2 group reached statistical significance.26

The means and standard deviations for accuracy are provided in Table 4. The ANOVA for accuracy produced main effect for Group, $F_1(1, 67) = 15.82, p < .001$; $F_2(2, 474) = 211.59, p < .001$. Verb Type was not significant in either of the analyses, $F_1(1, 67) = 2.07, p = .155$; $F_2(1, 237) = .269, p = .692$. The Group × Verb Type interaction did not reach the significance threshold either, $F_1(2, 134) = 0.913, p = .459$; $F_2(2, 474) = 0.389, p < .817$. Tukey’s post hoc pairwise comparison showed a significant difference between the performance of the Native group, on one hand, and the L2 and Heritage groups, on the other hand ($p < .001$ and $p < .01$, respectively). Thus, in accuracy, the Native group surpassed both the Heritage and L2 groups.

Next, two by-subject and by-item ANOVAs for RTs and accuracy with Group (Heritage and L2), Proficiency (high and low), Frequency (high and low), Verb Type (-aj-, -i-, and irreg), and Condition (unmatched and matched) as independent variables were performed for the learner data only.

The ANOVA on the RT data showed main effects of Group, $F_1(1, 53) = 9.03, p < .01$; $F_2(1, 106) = 146.78, p < .001$, Frequency, $F_1(1, 53) = 47.49,$
Table 4 Accuracy means for Experiment 2: Heritage, L2, and Native groups

| Type of stimuli and verb classes | Heritage | | | | L2 | | | | Native | | |
| | | | | | | | | | | | | |
| | M | SD | M | SD | M | SD | |
| **Real verbs: matched condition** | | | | | | | |
| -aj- | 0.88 | 0.08 | 0.89 | 0.08 | 0.94 | 0.05 |
| -i- | 0.90 | 0.05 | 0.90 | 0.06 | 0.88 | 0.11 |
| irreg | 0.86 | 0.10 | 0.86 | 0.09 | 0.87 | 0.05 |
| **Real verbs: unmatched condition** | | | | | | | |
| -aj- | 0.78 | 0.10 | 0.78 | 0.08 | 0.78 | 0.12 |
| -i- | 0.74 | 0.12 | 0.75 | 0.11 | 0.76 | 0.08 |
| irreg | 0.74 | 0.14 | 0.71 | 0.11 | 0.76 | 0.11 |
| **Nonce verbs** | | | | | | | |
| -aj- | 0.74 | 0.08 | 0.74 | 0.08 | 0.76 | 0.03 |
| -i- | 0.78 | 0.07 | 0.74 | 0.08 | 0.71 | 0.06 |
| irreg | 0.77 | 0.07 | 0.74 | 0.09 | 0.78 | 0.08 |

$p < .001; F_2(1, 106) = 32.51, p < .001$, Condition, $F_1(1, 53) = 157.23, p < .001; F_2(1, 106) = 179.34, p < .001$, and Verb Type, $F_1(2, 106) = 5.75, p < .001$, which was only significant in the by-subject, but not by-item, analysis, $F_2(2, 212) = 1.36, p = .262$. The ILR variable was significant in the by-item, but not by-subject, analysis, $F_1(1, 53) = 1.94, p = .169; F_2(1, 106) = 11.36, p < .01$. Thus, all of the tested variables were significant, with Verb Type and ILR showing less robust effects. The following two-way interactions were significant: Group × Verb Type, $F_1(2, 106) = 3.69, p < .05; F_2(2, 212) = 3.94, p < .05$, Condition × ILR, $F_1(1, 55) = 10.24, p < .01; F_2(1, 109) = 7.85, p < .01$, and Condition × Verb Type, $F_1(1, 53) = 3.75, p < .05; F_2(1, 106) = 1.27, p = .283$, the latter significant only in the by-subject analysis. Another interaction, Group × ILR, was significant only in the by-item analysis, $F_1(1, 53) = .483, p = .49; F_2(1, 106) = 11.36, p < .01$. To summarize, the two learner groups differed in their treatment of the different verb types, and, overall, the priming effect depended on the ILR proficiency level and the Verb Type.

A set of Tukey multiple comparisons were performed in order to determine whether the two learner groups treated the verbs, which varied in morphological complexity, in a similar fashion. Heritage learners did not show any preference for one verb type over the other. Their RTs were very similar across verbs, and no contrasts within the Heritage group were significant ($p = .996, p = .881$, and
Table 5  Mean reaction times, priming effects, and standard deviations (in parentheses) for regular (-aj-), semiregular (-i-), and irregular verb classes

<table>
<thead>
<tr>
<th>Target condition</th>
<th>Verb class</th>
<th>Matched</th>
<th>Unmatched</th>
<th>Priming effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heritage</td>
<td>-aj-</td>
<td>860 (85)</td>
<td>1,027 (108)</td>
<td>+166</td>
</tr>
<tr>
<td></td>
<td>-i-</td>
<td>892 (44)</td>
<td>981 (117)</td>
<td>+89</td>
</tr>
<tr>
<td></td>
<td>irreg</td>
<td>835 (68)</td>
<td>1,043 (135)</td>
<td>+207</td>
</tr>
<tr>
<td>L2</td>
<td>-aj-</td>
<td>997 (67)</td>
<td>1,113 (51)</td>
<td>+116</td>
</tr>
<tr>
<td></td>
<td>-i-</td>
<td>1,041 (69)</td>
<td>1,128 (68)</td>
<td>+87</td>
</tr>
<tr>
<td></td>
<td>irreg</td>
<td>1,024 (73)</td>
<td>1,200 (74)</td>
<td>+176</td>
</tr>
<tr>
<td>Native</td>
<td>-aj-</td>
<td>867 (33)</td>
<td>1,039 (45)</td>
<td>+172</td>
</tr>
<tr>
<td></td>
<td>-i-</td>
<td>963 (68)</td>
<td>1,148 (38)</td>
<td>+185</td>
</tr>
<tr>
<td></td>
<td>irreg</td>
<td>905 (19)</td>
<td>1,076 (70)</td>
<td>+171</td>
</tr>
</tbody>
</table>

Note. The priming effects are all significant, at least, at $p < .05$.

$p = .990$ for contrasts between -aj- and -i-, between -i- and irreg, and between -aj- and irreg, respectively). Conversely, L2 learners were sensitive to the verb types that ranged in morphological complexity. The L2 group responded to the -aj- verbs significantly faster than the -i- and irreg verbs ($p < .05$ and $p < .001$, respectively), whereas the responses to the -i- and irreg verbs did not differ significantly ($p = .913$).

To summarize the results for the RT analyses, Experiment 2 showed a significant facilitatory morphological priming effect in all three participant groups. Table 5 reports the mean RTs and standard deviations for the three groups to the three verb types and separately for the unmatched and matched conditions, averaged for two frequency ranges. The last column represents the priming effects calculated as the difference between the mean RTs in the unmatched and matched conditions. The comparison of the RT means revealed slower reaction times in the L2 than in the Heritage group. The significant priming effect goes in the predictable direction: faster responses to the primed targets. Token (lemma) frequency of the targets also showed a predictable effect: shorter responses to high-frequency verbs. Remarkably, there was no main effect found for the proficiency level (ILR) or Verb Type. However, the interaction between Condition and ILR reflects the fact that higher proficiency learners show a stronger priming effect. The interaction between Condition
and Verb Type refers to irregular verbs, which show a stronger priming effect than the other two verb types. Finally, based on Tukey’s post hoc pairwise comparisons of Verb Types within each learner group, a lack of effect for the Heritage group, and significant differences between RTs to the -aj- verbs, and two other verb types, -i- and irregular, in the L2 group, are demonstrated. Heritage speakers did not show differences in RTs depending on the Verb Type, whereas L2 learners took longer to respond to semiregular and irregular verbs, which were more difficult to decompose due to more complex allomorphy.

The accuracy ANOVA revealed main effects for Group, $F_1(1, 55) = 5.56, p < .05; F_2(1, 109) = 16.41, p < .001$, which was only marginally significant in the by-subject analysis, Frequency, $F_1(1, 55) = 216.85, p < .001; F_2(1, 109) = 79.50, p < .001$, Condition, $F_1(1, 55) = 103.87, p < .001; F_2(1, 109) = 161.42, p < .001$, and Proficiency, $F_1(1, 55) = 14.94, p < .001; F_2(1, 109) = 79.58, p < .001$. Verb Type was significant only in the by-subject, $F_1(2, 110) = 9.81, p < .001$, but not by-item analysis, $F_2(2, 218) = 2.05, p = .134$. The following two-way interactions were also significant: Group × Condition, $F_1(1, 55) = 5.97, p < .05; F_2(1, 109) = 9.75, p < .01$, Group × Verb Type, $F_1(2, 110) = 5.66, p < .01; F_2(2, 109) = 3.57, p < .05$, Condition × Frequency, $F_1(1, 55) = 41.71, p < .001; F_2(1, 109) = 34.22, p < .001$, and Verb Type × Frequency, $F_1(2, 110) = 23.43, p < .001; F_2(2, 109) = 4.38, p < .01$.

To summarize, the Heritage group performed better than the L2 group, and both the priming effect and ILR proficiency level were found significant. Verb Type showed a weaker effect, and it depended on the group.

In order to test our claim that complexity in decomposition and mapping of primes and targets will affect the latencies in the matched condition whereas only decomposition of the target will affect the latencies in the unmatched condition, we conducted further analyses of the RTs for irregular verbs separately and subdivided the verbs by the kind of morphonological processes affecting their allomorphy. Figures 1 and 2 illustrate the effects obtained for the unmatched and matched conditions only for nonnative data. L2 learners are slowed down the most by irregular infinitives in the unmatched condition and by the verb types involving complex mapping, such as consonant changes and appearing vowels, in the matched condition. Heritage speakers do not show great differences in RTs depending on the type of allomorphy in the unmatched condition. Again, auditory processing of inflected verbs in heritage speakers is less affected by morphonological processes, which together with significantly shorter RTs suggests less reliance on decomposition in auditory verb recognition.
Discussion
This study compared the processing of Russian inflected verbs in an auditory priming experiment with two nonnative groups—late L2 learners and heritage speakers—and a group of native controls. It was based on several assumptions: (a) There is no categorical difference between regular and irregular inflection in Russian; (b) decomposition of inflected verbs is automatic; and (c) most inflected verbs used in the experiment have whole-word frequencies falling...
below the (unidentified) threshold for whole-word storage in Russian. The results of the study, with the priming effects obtained for regular, semiregular, and irregular verbs, support the claim that no categorical dissociation between regular and irregular processing was involved in this task. Moreover, the largest priming effects were obtained for the irregular verbs—the ones that did not show any priming effects in a study of English past tense inflection (Marslen-Wilson et al., 1993). There are several possible reasons why this particular verb type showed the largest priming effect. Irregular verbs are shorter than other verb types in Russian; therefore, they could not have required more time to be taken in auditorily. Conversely, given that they were short (monosyllabic and disyllabic), they may have been difficult to process and, thus, priming helped to access them more quickly. Some irregular infinitive targets had low-type-frequency “irregular” endings and could have taken longer to process; hence, there was a stronger advantage of the matched condition. Overall, comparisons of RTs to different subgroups of irregular verbs in the unmatched and matched conditions supported the hypothesis that the latencies in the unmatched condition depend on ease of decomposition and type frequency of inflections, whereas in the matched condition, the latencies are additionally influenced by the complexity of mapping between the prime and the target.

The main goal of the study was to identify differences in two groups of nonnative speakers, early heritage learners, and late L2 learners at the same proficiency levels. In fact, several differences have emerged. First, heritage speakers’ responses were generally faster than those of L2 learners. Second, unlike L2 learners, heritage speakers were not sensitive to the verb type and complex allomorphy, as reflected in their relatively uniform RTs. Conversely, L2 learners were faster in response to the regular default -aj- verbs than to semiregular -i- and irregular verbs. The size of the priming effect did not depend on the participant group, although it was greater in the higher proficiency range.

**General Discussion**

As evident in the title, this article explores the role of regularity in non-native processing of inflectional morphology and presents the data on production and perception of Russian inflected verbs supporting the claim that the regular/irregular dichotomy does not correspond to any categorical division observed in the data. Rather, the obtained results of both experiments point in the direction of (a) a major role of allomorphy involved in (de)composition and mapping of two forms in the case of priming; (b) type frequency, here referring to the frequency of the conjugational pattern; and
the use of probabilities, all of which contribute to the choice of the appropriate stem and inflection. Based on the data on English and Swedish whole-word (lemma) effects for inflected words above a certain threshold (Alegre & Gordon, 1999; Lehtonen et al., 2006) and nonnative preference for decomposition (Portin et al., 2007a), most verbs used as stimuli in both experiments were expected to be processed by (de)composition, especially in nonnative speakers. Additionally, there are indications that decomposition is automatic, provided the inflection is easily detached and highly recognizable, even with nonce stems (Marslen-Wilson & Tyler, 2007). It should be noted, however, that although decomposition of inflected verbs into stems and inflections is likely to be automatic, further decomposition of stems into roots and suffixes, which involves dealing with complex allomorphy, is expected to depend on morphophonological complexity.

Experiment 1 on real and nonce verb generation has demonstrated that similarly to native speakers, highly proficient late L2 learners and heritage speakers applied all of the patterns, ranging in regularity and type frequency, to novel verbs. The choice of the conjugational pattern in novel verb processing was guided by implicit knowledge of probabilities, and efficiency in the retrieval of morphological cues to the inflectional pattern, and application of complex morphophonological rules. The results of Experiment 1 indicate that heritage speakers and late L2 learners differed in their processing of the verb classes ranging in the degree of regularity, productivity, and type frequency, with heritage speakers showing an input-driven processing advantage and outperforming L2 learners on the use of statistical probabilities and the default pattern. L2 learners were better at the use of morphological cues and complex allomorphy involving suffix alternation, which could be attributed to more reliance on structural knowledge. Thus, early implicit native input in heritage speakers and late explicit input in L2 learners influenced their choice of conjugational patterns and accuracy in verb generation.

Experiment 2 demonstrated the priming effects in regular, semiregular, and irregular verb recognition in all three groups. It did not support a categorical dissociation between regular and irregular processing of Russian verbal inflection because all of the verb types produced a priming effect. Automatic morphological decomposition is claimed to be part of the dorsal stream (Marslen-Wilson & Tyler, 2007). Given that L2 learners showed long RTs and the priming effects to all of the tested verb types, with the longest RTs and greatest priming effects to irregular verbs with complex allomorphy, they were probably relying on decomposition. Remarkably, heritage speakers showed the fastest RTs and little sensitivity to morphophonological complexity involved in decomposition.
and mapping of different verb types. High speed in lexical access is associated with the lack of decomposition cost and, therefore, provides evidence for whole-word processing (Lehtonen & Laine, 2003). This tentatively suggests that heritage speakers may use the decompositional (dorsal) pathway less than L2 learners and may process inflected verbs in auditory lexical access by relying more on the semantic (ventral) stream. At the same time, heritage speakers differed from L2 learners in the absence of significant differences in RTs to different verb types, either in the unmatched or matched conditions. A comparison of language learning backgrounds of L2 learners and heritage speakers indicates that heritage learners received early implicit native input, whereas L2 learners received late input, both implicit and explicit. Late L2 learners had formal instruction in Russian, including explicit instruction in Russian grammar, whereas heritage speakers had very little or no formal schooling. L2 learners received abundant written Russian input; however, naturalistic auditory native input was significantly smaller in L2 learners than in heritage speakers. High reliance on auditory rather than written input and lack of formal schooling in the structural aspects of Russian verb conjugation may be both responsible for faster RTs and possibly less decomposition in heritage processing of auditory stimuli. L2 learners, unlike heritage speakers, demonstrated high sensitivity to morphological complexity in recognition of inflected verbs, which is apparently due to a higher dependence on decomposition, less experience with auditory input, and weaker control of low-frequency inflectional patterns leading to slower lexical access in L2 learners. Interestingly, the differences observed in heritage and L2 auditory processing of morphologically complex words are opposite to the ones observed in visual processing of Swedish inflected words by L1 speakers of Hungarian and Finnish (Portin et al., 2007a) with regard to the role of formal instruction. Apparently, formal instruction develops whole-word representations of the visual input (enhanced in L1 Finnish learners of Swedish) but not of the auditory input (not enhanced in L2 Russian learners). The differences in RTs and sensitivity to morphological complexity suggest differences in the mechanisms underlying L2 and heritage processing of inflectional morphology. Although differences between L2 and heritage processing of inflection documented in this study need further research, these tentative findings do not support the prediction of the declarative/procedural model that early learners will rely more on decomposition than late learners. It seems plausible that formal schooling with explicit instruction in verb conjugation plays an important role in shaping the mechanisms of morphological decomposition. However, the fact that highly proficient late L2 processing was slower and more affected by
complex allomorphy than heritage processing indicates that decomposition presents difficulties for late L2 learners. Taken together, these two pieces of information may mean that late L2 recognition of inflected words is less efficient because, on the one hand, it relies on decomposition, with whole-word representations of inflected words being unavailable, and, on the other hand, decomposition is slower and more affected by morphological complexity compared to native speakers. This interpretation is compatible with the tenets of skill acquisition theory, with proceduralization of grammar (in this case morphological [de]composition) taking place over time in late L2 learners (DeKeyser, 2007). Of course, the connection of these processing data with neurological data is still in the future; however, some observations collected in this study could be used to bring together different research agendas. Thus, the differences in the processing of inflectional morphology observed in our nonnative participants can be associated with their language learning backgrounds and, possibly, their reliance on different neural paths. As a baseline, one can hypothesize that native speakers receive early and abundant native input and formal instruction in Russian and can easily rely either on decomposition or whole-word processing, tentatively corresponding to the dorsal and ventral pathways in the brain. Late L2 learners in the study received late explicit input in verb conjugation instead of early native input and had limited exposure to Russian compared to native speakers; consequently, they relied more on decomposition in lexical access and, possibly, the dorsal stream, but they were also limited in their control of inflection and the speed of access. Heritage speakers received early native input, but exposure to native input gradually diminished because they switched to English and did not receive proper instruction in Russian, either as the L1 or L2. As a result, they developed strategies that depend less on decomposition and more on whole-word processing and possibly rely more on the ventral stream in lexical access.

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Notes

1 There are only three verbs in Russian with suppletion considered truly irregular.
2 The comparison of the rules and probabilities model (Gor, 2003, 2004) with the usage-based approach, which have much in common, lies beyond the scope of this study. In short, the main difference is in the fact that the rules and probabilities model places more emphasis on the status of rules as abstractions of patterns derived from the input and on the role of the priors, or innate constraints on linguistic processing and language learning.
3 The blocking principle, to the contrary, expects the minor rules or irregular patterns to be applied first, thereby blocking the application of the more general rule.

4 The series of publications on the processing of polymorphemic words in Finnish and Swedish by monolinguals, bilinguals, and L2 learners used the same methodology. The studies matched polymorphemic and monomorphemic words on a set of parameters, such as word length, frequency, bigram frequency, and so forth, and interpreted significant delays in the processing of polymorphemic words compared to monomorphemic as an indication that polymorphemic words were decomposed in lexical access, with delays corresponding to the processing cost of decomposition, as opposed to whole-word access.

5 The main focus of the present article is on the differences in early and late L2 learners that accompany pure age differences, such as input and formal instruction, and, accordingly, it does not address directly the critical period theory. Therefore, the controversy surrounding multiple definitions of the critical period and the age when it ends are beyond the scope of this article. For a review, see, for example, DeKeyser and Larson-Hall (2005).

6 It should be noted that research on early bilinguals acquiring Finnish or Swedish as the L1 or L2 and similar research on early Catalan-Spanish bilinguals explores the hypothesis that not only the differences in the linguistic experience at the onset of learning but also the amount of language use, with the use of both the L1 and L2 limiting each other, lead to differences between bilingual and monolingual language proficiency. In doing so, it implicitly acknowledges the fact that L1 in early bilinguals may be developed incompletely compared to pure L1 monolinguals; thus, early bilinguals could be treated as highly proficient heritage speakers.

7 Stress shift is the only lexically assigned property of Russian conjugation, and it will not be addressed in this study.

8 In English, these neighborhoods are claimed to be organized based on phonological similarity (Prasada & Pinker, 1993) or, alternatively, on minor symbolic rules (Yang, 2002).

9 Although the one-stem verb description developed by Jakobson (1948) provides a system of rules making it possible to generate all the verb forms, its psycholinguistic status in native and L2 processing is unclear. For a psycholinguistic account of Russian verb conjugation, see Gor (2003).

10 Although the -aj- class is uncontroversially the default class, further research is needed to test the possibility that the broader “vowel + j” pattern is in fact the default pattern in Russian verb conjugation (see Gor, 2003).

11 The ILR (Interagency Language Roundtable) oral proficiency scale runs from level 0+ to level 5, which corresponds to “highly articulate well-educated native speaker.” ILR oral proficiency testing is widely used in U.S. government agencies. It has a rigid internal structure, is administered by certified testers, and is blindly...
second-rated. For more information, visit the Web site http://www.govtilr.org/Skills/ILRscale2.htm.

12 The labels “high” and “low” are arbitrary, as both subgroups, with few exceptions, include, at least, advanced speakers.

13 Although most heritage speakers switched to English at a young age (at least, before puberty), a few switched to English around puberty. Two questions arise: Why were they included in the participant group? Can they be considered native speakers? They were included because the study targeted highly proficient speakers of Russian, and based on the ILR oral proficiency test, they matched this criterion but did not perform as native speakers. Apparently, before puberty, with lack of exposure and practice, the L1 regresses—a point in need of further investigation.

14 For imperfective verbs, the non-past-tense refers to the present tense, whereas for perfective verbs, it refers to the future tense.

15 Reaction time data in production experiments with no time pressure are less informative than in controlled lexical decision task experiments and were not part of the research design.

16 The following three-way interactions were significant: Proficiency × Verb Class × Stimulus Type, \( F(4, 216) = 2.41, p < .05 \), and Verb Class × Stimulus Type × Frequency, \( F(4, 216) = 7.28, p < .001 \).

17 This statement is not a claim that early starters store inflected word forms; the experiment can only support the general advantage of heritage speakers, possibly related to the size of the mental lexicon and frequency of the stored lexical units.

18 The auditory presentation mode was dictated by the constraints of the larger funded project, which included the two reported experiments.

19 See, however, research on inflectional morphology in Polish, a Slavic language with a similar rich morphological system (e.g., Dabrowska, 2008).

20 For more details on ERP research and the findings pertaining to morphological processing, see the Commentary by De Diego-Balaguer and Rodriguez-Fornells (this issue).

21 See the section Russian Verb Conjugation for the description of the verb classes used in Experiment 2.

22 Morphological priming effects are facilitative and normally exceed semantic and phonological effects (Feldman & Soltano, 1999), with RTs to targets preceded by matched primes shorter than to targets preceded by unmatched primes.

23 For token frequency, we had to use cumulative lemma frequencies as the best available approximation, because for many inflected verbs, surface (whole-word) frequency was very low and irretrievable from the corpus.

24 The Russian Internet Corpus can be found at the Web site http://corpus.leeds.ac.uk/ruscorpora.html.

25 The entire priming experiment included phonological and semantic priming in addition to morphological priming. The results of the phonological and semantic...
priming are the topic of a separate publication (Gor, Cook, and Jackson, in preparation).

26 The fact that the Heritage group was faster than the Native group may be due to the differences in mean age—heritage speakers were significantly younger (mean age 36.7 and 22.5, correspondingly). However, this issue needs further research, because there are indications that this may be true for heritage speakers in general, as compared to monolinguals. Thus, Korean heritage speakers were faster than both Korean and English monolinguals in a study on phonological processing by Sunyoung Lee (UMD).

27 In addition, one three-way interaction was also significant —Verb Type × Frequency × Proficiency, $F_1(2, 112) = 4.57, p < .001; F_2(2, 212) = 5.26, p < .01$. Other interactions were not significant.

28 There were also two three-way interactions that reached the significance threshold: Group × Verb Type × Frequency, $F_1(2, 110) = 13.95, p < .001; F_2(2, 109) = 7.33, p < .001$, and Verb Type × Condition × Frequency, $F_1(2, 110) = 5.17, p < .01; F_2(2, 109) = 3.34, p < .05$. Other interactions were not significant.

References


Gor and Cook

Nonnative Processing of Verbal Morphology


