THE RULES AND PROBABILITIES MODEL
OF NATIVE AND SECOND LANGUAGE
MORPHOLOGICAL PROCESSING

One of the most controversial issues in the study of human language is whether the linguistic rules and operations postulated by linguists are psychologically real, or, in other words, whether the speaker-hearer indeed uses the abstract rules, the way they are described in linguistic theory, in speech processing. The aim of this paper is to argue that both native and second language (L2) processing of inflectional morphology make use of symbolic rules rather than analogies, and at the same time, they are influenced by the input frequencies. This claim will be supported by re-examining the experimental evidence on the processing of Russian complex morphology by adult native speakers and American learners of Russian. The paper will analyze the tenet of both the dual-system and single-system theories of morphological processing, and will demonstrate that neither theory can handle the results observed in adult L1 and L2 generation of Russian novel verbs. It will then discuss the presented evidence in the light of the Rule Competition Model, which was developed for child first language (L1) processing of English past-tense morphology, and show how it works for adult L2 acquisition as well. Finally, it will broaden the scope of the Rule Competition Model to native adult morphological processing and propose its own Rules and Probabilities Model. This model is at odds with the dual-system approach, which claims that symbolic rule processing of regular morphology is independent of input frequencies and immune to linguistic probabilities. At the same time, it is at odds with the single-system approach, which denies the existence of symbolic rule computation, and supports the idea of associative patterning based on statistical probabilities. Thus, the Rules and Probabilities Model combining both the symbolic rules and statistical probabilities constitutes a radical departure from either approach.
The Dual-System and Single-System Theories of the Processing of Inflectional Morphology

For the last two decades, research on the processing of verbal morphology has served as a testing ground for several competing theories aiming to explain how humans acquire and use language. In addition to the two opposite theoretical positions, known as the dual-system and the single-system approaches, there exist several “intermediate” positions, which combine different aspects of these approaches. The main debated issue is whether linguistic processing relies on abstract symbolic rules subserved by a computational system in addition to a complex network of associations between word-forms in memory. Most of the data fueling these debates come from the study of English past-tense inflexion, and the different approaches seek to establish whether regular and irregular past-tense verbs are processed by the same mechanism or not. The dual-system approach views morphological processing as a combination of two distinct mechanisms: regular morphology is processed by symbolic rule application, while irregular morphology is processed by analogy-based associative patterning in memory (Marcus, Pinker, Ullman et al. 1992; Marcus, Brinkmann, Clisham et al. 1995; Pinker 1991; Pinker, Prince 1988; 1994; Prasada, Pinker 1993; Jaeger, Lockwood, Kemmer et al. 1996; Ullman 1999). According to the single-system approach, there exists only one mechanism for processing both regular and irregular morphology, which resides in associative memory (Bybee 1985; 1995; Langacker 1987; 1988; MacWhinney, Leinbach 1991; Plunkett, Marchman 1991; 1993; Rumelhart, McClelland 1986). Since lexical connections are established based on phonological and semantic mappings, phonological similarity lies at the core of analogy-based processing.

The main difference between symbolic rule computation and associative patterning is that the former does not depend on any conditions external to linguistic constraints, while the latter depends on linguistic probabilities, such as input frequencies available to the speaker in virtue of linguistic experience. In other words, the strength of mappings between two word-forms in associative patterning depends on the frequency of these mappings, with the more frequent ones being easier to retrieve from memory.

One of the most influential “intermediate” positions, the dual-route or dual-access theory, postulates that symbolic rule application and the search in associative memory for inflected word-forms proceed parallel to one another, and the fastest route wins the competition (Bayen, Dijkstra, Schreuder 1997). Therefore, in visual perception of the word stimuli, the dual-access theory predicts that for high-frequency complex words, the direct access route will win, while for low-frequency complex words the decomposition route will win. Another “intermediate” position is expressed in the Mental Model of Morphology (Ullman 2000) put forward by the supporter of the dual-system approach. This model also posits the existence of two systems, a symbolic rule processor and associative memory, which both take part in morphological transformations. However, this model does not presuppose that the two types of processing work in parallel, on the contrary, following the dual-system approach, it makes use of the blocking principle. Generally speaking, in linguistics the blocking principle suggests that the more specific rule is applied before the more general rule. In the case of English past-tense processing, it implies that successful search in associative memory and retrieval of an irregular past-tense form stored there block the application of the regular -ed rule. The dual- and single-system approaches espouse opposite views on the role of input frequencies in morphological processing. The dual-system approach claims that the nature of symbolic rules is such that their application takes place regardless of the frequency of the rule (type frequency). In addition to that, the frequency of the word-form (whole-word frequency) does not influence verbal processing either, since regular verbs are not stored in their inflected forms. The only frequency, which may show effects in verbal processing, is stem-cluster frequency, which reflects the frequency of the lexeme. The other frequency effects mentioned above are reserved for irregular verbs. This follows from the fact that irregular verbs are stored in associative memory, and therefore the strength of their memory traces depends on their frequency of occurrence.

Also, irregular verbs form neighborhoods based on phonological similarity and demonstrate the phonological similarity effect. According to the single-system approach, since both regular and irregular verbs are processed in associative memory, they will show frequency and phonological similarity effects.

The single-system approach is developed within two main directions, the network (Bybee 1995; Langacker 1987; 1988) and the connectionist (MacWhinney, Leinbach 1991; Plunkett, Marchman 1991; 1993; Rumelhart, McClelland 1986) approaches. According to the network model (Bybee 1995), both simple and inflected words are stored in associative memory and form phonological and semantic associations. The word’s lexical strength depends on its token frequency, while the strength of lexical connections between words depends on the frequency of the pattern (schema). Type frequency, within this model, is related to the productivity of a given pattern. The network model distinguishes between productivity, regularity, and default, with default characterized by the most open schema and being used when all else fails. The regular pattern shows the least allomorphy in affix and stem (Bybee 1995;
The single-system approach denies the existence of the morphological level of processing and relies completely on phonological mappings between word-forms. According to Joan Bybee, "Words entered in the lexicon are related to other words via sets of lexical connections between identical and similar phonological and semantic features. These connections among items have the effect of yielding an internal morphological analysis of complex words..." (ibid.: 428). Several studies have challenged this position by providing evidence that the type of the affix (a morphological category) and its properties affect the processing of complex words (Baayen, Dijkstra, Schreuder 1997; Bertram, Laitin, van Heuven 1999; Bertram, Schreuder, Baayen 2000). These studies have demonstrated the influence of word formation type (inflection versus derivation), productivity, and affix homonymy on the processing of complex Dutch and Finnish words using a lexical decision task with visual presentation of the stimuli. If indeed these factors play a role in word access, this implies that the morphological level is part of word representations in the mental lexicon, and phonological representations are only part of a more complex system of representations. Thus, the article on the processing of singulars and plurals in Dutch states that "approaches in which these specific properties of affixes and the word formation patterns in a given language are not taken into account are severely limited" (Baayen, Dijkstra, Schreuder 1997: 112). Additional support for the dissociation between derivational and inflectional morphology comes from the studies of aphasia (Caramazza 1997: 142). The dual-system approach claims that since the inflected forms of regular verbs are not stored in memory but processed by rule computation, they will not show type and token (whole-word) frequency effects or phonological similarity effects. However, the results obtained for English are controversial, with the most recent and rigorously conducted lexical decision study showing the whole-word frequency effect for the regular inflected verbs with the frequency above 6 per million, when stem-cluster frequency was held constant (Alegre, Gordon 1999). These data suggest that the inflected forms of the verbs are indeed stored in the mental lexicon contrary to the predictions made by the dual-system approach. The weak version of dual-system approach allows for a certain number of very high-frequency regular verbs to be stored in their inflected form (Prasada, Pinker 1993). However, the 6 per million threshold suggests that a great number of regular verbs is stored in their inflected forms, considerably more than the dual-system approach predicts.

The dual-system approach explains past-tense processing in English by the blocking principle (Marcus, Pinker, Ullman et al. 1992: 8 ff), according to which past-tense inflection begins with search in memory for the stored irregular form. If such form is successfully retrieved, this blocks the application of the symbolic -ed rule. If no irregular form is retrieved, the -ed rule is applied. The blocking principle is widely used in linguistic analyses and refers to the mechanism whereby the more specific rule takes precedence over the more general rule and blocks its use. It explains overregularization errors of the type hold instead of held for children — their memory traces for irregular verbs are not sufficiently strong, and as a result they fail to retrieve the irregular form, and apply the regular -ed rule instead. There are several problems with the use of the blocking mechanism to explain the processing of past-tense morphology. First, it presupposes that only regular past-tense verbs are stored, but the whole-word frequency effects for regular inflected verbs in a lexical decision task raise the threshold of 6 per million (Alegre, Gordon 1999) challenge this claim. Second, several studies have found that the processing of regular verbs takes less time than the processing of irregular verbs (Jaeger, Lockwood, Kemmerer et al. 1996), while the blocking mechanism should lead to exactly the opposite effect. Indeed, if the rule is not applied until the search for irregular form is completed, irregular verbs should require less processing time. And finally, children acquiring English make more overregularization errors (hold instead of held) than overregularization errors (think instead of thought). If the blocking mechanism had been in place, they would have erred in favor of another irregular form, when they fail to retrieve the appropriate irregular form (Yang 2002). Thus, the sharp dichotomy between symbolic rule application and associative patterning, and the blocking mechanism underlying this dichotomy are not supported by the experimental data. However, the English data support one prediction of the dual-system approach, namely, that phonological similarity influences the processing of irregular verbs, which form neighborhoods, and does not influence the processing of regular verbs. And indeed, English regular verbs do not show phonological similarity effects (Ullman 1999).

The juxtaposition of regular and irregular morphological processing is well justified for English, at least at the descriptive level, however, it is much less meaningful for languages with complex morphology, in which regularity can become a gradual parameter, and the opposition of default and non-default processing becomes more relevant. Before we turn to the Russian data, we will briefly overview the findings on verbal processing in Icelandic, Norwegian, Icelandic, languages with developed conjunctive paradigms, and German, whose inflectional morphology occupies an intermediate position — it is richer than in English, but less rich than in Icelandic.

Controversial Evidence on Languages Other Than English

Research on languages with numerous verb classes and a developed conjunctive paradigm, Icelandic, Norwegian, and Italian, has demonstrated that for these languages there is no clear-cut difference between regular and
irregular verb processing (Ragnarsdóttir, Simonsen, Þúdpó 1997; Matovich 1998; Olshtain, Marslen-Wilson 1979; Olshtain, Famtir, Bowers 1998; Simonsen 2000). All these studies have found the influence of frequency and phonological factors on the processing of all the verb classes, including the regular default classes, both in children and adults. For example, the Norwegian verb generation data by 4, 6, and 8-year-old children and adults has produced the following results (Simonsen 2000): (13) All three major verb classes are acquired in an order reflecting their type frequency — first, the larger weak (regular), then, the smaller weak, and finally, the strong (irregular) class. (2) The higher the type frequency, the more likely it is that the class will be the basis for overgeneralization. (3) Younger children showed a token frequency effect not only for the strong class, but also for the larger weak class, which can be considered the default class. (4) The influence of phonological similarity on adult verb generation manifested itself in the rhyme effect — i.e., a poorer performance on weak verbs rhyming with strong verbs than on those not rhyming with strong verbs. (5) Younger children did not show the rhyme effect, presumably, because their knowledge of strong verbs was insufficient; however, they made use of the cue provided by the word tone to distinguish between strong and weak verbs. These results led the author to refute the dual-system model, which predicts no influence of frequency and phonological factors on default processing, and to embrace the single-system model, which predicts the influence of input factors on all verb classes (Simonsen 2000: 97-99). However, some facts observed in Norwegian verb processing suggest that type frequencies of the verb classes alone do not explain the rates of correct performance in adults. Thus, the highest rate of correct performance is found in the smaller weak class, and not in the default larger weak class. Apparently, some other factors, such as segmentability, or stem changes, salience of the past tense suffix (whether it is syllabic or not), phonological openness and coherence of the verb class all play a role in verbal processing in Norwegian. These observations indicate that the frequency of phonological mapping postulated by the single-system approach is not sufficient to handle the obtained results. The comparison of the child and adult generalization errors shows a pronounced developmental tendency — moving away from the default larger weak class pattern to the smaller weak class pattern. A similar developmental pattern is observed in Russian children (see Gori, Chernigovskaya 2003b). At least one study challenges the results discussed above. This study compares the performance on verb generation task of 3 bilingual Norwegian-English children aged 3.8, 5.9, and 7.9, and supports the dual-system approach on the grounds that the children performed better on the strong (irregular) verbs than on the smaller weak verbs (Jennison 2003). The type frequency of the smaller weak verbs is considerably higher than that of the strong verbs, which means that this result cannot be attributed to the role of input frequency predicted by the single-system approach. These data, which are in conflict with the data obtained for a group of 30 Norwegian children, require confirmation with a larger group of subjects. Generally speaking, it comes as no surprise that the studies conducted on morphologically complex languages tend to find support for gradual transitions between regular and irregular processing, and as a result, typically support the idea expressed by the single-system model that both regular and irregular verbs are processed by the same mechanism. A series of studies on the processing of German inflectional morphology supports the opposite, dual-system model of morphological processing (Clahsen 1999). The analysis of the experimental data on German inflection (ibid.) is the most comprehensive one for any language other than English. It uses a variety of experimental techniques — sentence matching, cross-modal morphological priming, lexical decision tasks, and an event-related potentials study — with adult and child subjects to investigate the processing of German past participles and noun plurals. Harald Clahsen claims that, in German, as in English, there exist two qualitatively different types of inflection, lexically based inflection and inflection based on combinatorial rules (ibid.: 994). Following Steven Pinker, he equates lexically based inflection with irregular inflection, and rule-based inflection with regular (default) inflection. There is a caveat one needs to be aware of when accepting this equation for English, and even more so if one is to consider other languages with complex inflectional morphology. Clahsen uses the term "default" in parentheses alongside the term "regular", and apparently this indicates that these terms can be used interchangeably. Equating regular and default processing definitely needs a justification; in fact, it is possible that some of the results obtained in the study of German inflection can be accounted for by this confusion over different processing mechanisms. The series of studies reported by Clahsen indeed demonstrates the differences in the processing of different classes of participles and noun plurals that are consistent across different experimental paradigms. While the division into regular and irregular morphology suggested by Clahsen is highly controversial, with 93% of German nouns belonging to irregular inflectional types (162), the difference in processing still need to be explained. And this explanation potentially lies in a deeper analysis of default processing. Two main factors weaken the theoretical position adopted by Clahsen as well as his interpretation of the obtained results: (1) the idea that losing word forms and accounting for them by rule are mutually exclusive, and (2) the lack of differentiation between regular and default processing. Thus, the fact that both adults and children generalize the plural -s inflexion despite the fact that it is extremely rare in the input (102) demonstrates the use of default, since the -s affix has the most open distribution in German. (Note, however, that only 58.3% of the child overregularizations were with -s plural, the rest used other plural affixes.) Other affixes are overgeneralized less often because their distribution is much more restricted than the distribution of the -s plural.
From the Rule Competition Model (Yang 2002) to the Rules and Probabilities Model

Charles Yang, who studied under Noam Chomsky at MIT, has developed a model of child first language (L1) acquisition of English regular and irregular verbal morphology, which is a radical departure both from the dual- and single-system approaches (Yang 2002). He has tested the Rule Competition Model by analyzing the published CHILDES data for four American children (Marcus, Pinker, Ullman et al. 1992) and found that the Rule Competition Model has a better fit to the data than Pinker’s dual-system Words and Rules Model (Pinker 1999). Yang claims that all the English verbs in child L1 acquisition are conjugated based on phonological rules, while the role of analogies is very peripheral, and talks about the “fuzziness” of the “family resemblance” concept. These phonological rules, including suffusion and reduplication, can be more general (as in regular verbs) and can also cover a small set of items (as in irregular verbs). This position stems out of generative phonology, and parallels the major version-mirror rule dichotomy (Chomsky, Halle 1968; Dressler 1999).

Crucial to the understanding of the Rule Competition Model is the differentiation between rules and analogies, since it operates with rules and not analogies. The notion of analogy is built on phonological similarity, whereas rules operate on abstract linguistic concepts. For example, English irregular verbs clusters into neighborhoods organized according to analogy by rhyme, such as sing-sang, ring-rang, cling-clang (but bring-brought). Examples of phonological rules include (based on Yang 2002):

**Suffix -t & Vowel Shortening**
- Love-lost
- Leave-leave

**Suffix -s & No Change**
- Putput
- Hit-hit
- Cut-cut

**Suffix -o & Backing Ablaut**
- Get-got
- Take-took
- Write-wrote

The child L1 empirical evidence demonstrates that the abstract rules, not only analogy by rhyme, can handle the observed acquisition patterns. According to the Rule Competition Model, in child L1 acquisition, rules have weights, these weights being adjusted with more input. The Rule Competition Model replaces the absolute blocking principle assumed in the Words and Rules Model with a stochastic version of the blocking principle, which states that a more specific rule overrides the default rule with a probability. Thus, the probability that a certain pattern will be applied is a function of the individual weight of the verb and of the weight of the rule. The verb weight is defined by its token frequency, while the rule weight is determined by the number of uses of all the verbs belonging to a particular class in the input to the child. The competition takes place between an irregular and the default rule. Yang proposes the Free-Rider Effect to explain how the frequency of the rule affects the rates of correct use for irregular verbs in child L1 acquisition of English. The Free-Rider Effect refers to a situation where high type frequency enhances the probability that a certain rule will be chosen to inflect a certain word.

Yang’s model is inspired by Darwinism and the theory of evolution, and combines two seemingly irrecocilcable theoretical positions held by researchers working in the Universal Grammar and learning paradigms. As a result, the model combines linguistic knowledge (Universal Grammar) and learning.

It is true that Yang’s Rule Competition Model is the most articulate and argued position in favor of the interaction between rules and probabilities. However, it is also true that recent years have been marked by a gradual process of bridging the gap between the two extreme positions supported by the dual- and single-system approaches. Not surprisingly, the greatest advances in justifying the role of frequencies in linguistic processing have been made in research on second language acquisition (SLA) (Ellis 2002). The reason for this lies in the inherently variable nature of second language processing and a heightened attention of SLA research to the variability agenda. But it is quite remarkable that the single-system approach is beginning to admit the abstract level of processing into its model. Thus, Ellis (ibid.) and Bybee support the view that in categorization, “a more abstract prototype is constructed based on the stored exemplars” (Bybee 2002: 219). In accordance with that, the focus shifts to type (as opposed to token) frequency, and it is given a key role in language acquisition (Ellis 2002: 148).

The aim of this paper is twofold. First, it will extend the ideas expressed in the Rule Competition Model, notably, that symbolic rules have weights, which determine the probability of the use of this particular rule versus other rules competing with it, from child L1 acquisition to adult second language (L2) acquisition. Second, it will extend the idea that rules and probabilities interact to native adult processing. While the rule competition in Yang’s sense, when the child has different rules attached to the verb stem with certain weights, should be resolved in adults, the paper will put forward a more radical proposal that linguistic processing is based on probabilities in a sense that the more frequent rules are applied or at least considered first. This position challenges the blocking principle and the underlying idea that the minor rules are applied before the major ones for linguistic processing. The paper will treat the Roles and Probabilities Model against the set of data on verb generation by native
**Russian Conjugation System**

A short discussion of the Russian verb system will precede the analysis of the experimental material. According to the one-stem verb system (Jakobson 1948), Russian has 11 verb classes, each with its own suffix, or verbal classifier. The eleventh class has a zero suffix, and is subdivided into smaller subclasses depending on the quality of the root-final consonant. This is a small class, especially given the variety of conjugational patterns it includes, and there are well over 100 basic stems in it (Townsend 1975).

The conjugational patterns of some of the sub-classes of the non-suffixed stems have idiosyncratic features, and thus form verb clusters, which can be compared to the neighborhoods of English irregular verbs, or alternatively, characterized by the minor rules. The remaining 10 suffixed classes are identified by the suffixes: -

d (e) -


d (e) -


d (e) -


d (e) -


d (e) -


d (e) -


d (e) -


d (e) -


d (e) -


d (e) -


including the "disappearing -"...

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The suffix determines all the parameters of the conjugational paradigm, including the choice of the thematic vowel in the inflections (1st or 2nd conjugation), and different types of stem changes see Table 1). When the endings are added to the stem (which includes the optional prefix, the root, and the suffix), an automatic truncation rule works at the juncture of the stem and the ending. If the stem ends in a vowel and the ending begins in a vowel, the first vowel is truncated. The same is true for the consonants: the first one is deleted. Past tense and infinitive endings begin with a consonant, and non-past tense endings begin with a vowel, therefore, stem-final vowels will be deleted in non-past tense forms, and consonants will be deleted in past tense and infinitive forms.

Overall, the Russian verbal system possesses the following features:

- Numerous verb classes;
- Developed conjugational paradigms;
- No sharp division between regular and irregular classes;
- Several regular classes in addition to default;
- Influenkes of many verb classes have unchangeable stems due to the truncation of the stem-final consonant before consonantal endings.\[\text{\textsuperscript{1}}\]

\[\text{\textsuperscript{1}}\] The consonant "26" represents any palatal consonant— a fleeting or "7"— and is not part of the suffix.

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Table 1 lists the morphological processes shaping the conjugational patterns of the stems chosen for the experiments. It does not include automatic consonant or vowel truncation, which occurs at the juncture of the stem and the ending.

<table>
<thead>
<tr>
<th>Verb classes and subclasses</th>
<th>-(\text{\textsuperscript{26}})</th>
<th>-(\text{\textsuperscript{21}})</th>
<th>-(\text{\textsuperscript{2}})</th>
<th>-(\text{\textsuperscript{3}})</th>
<th>-(\text{\textsuperscript{26}\text{\textsuperscript{3}}})</th>
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<th>-(\text{\textsuperscript{26}\text{\textsuperscript{1}}})</th>
<th>-(\text{\textsuperscript{1}})</th>
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<tbody>
<tr>
<td>Consonant Mutation</td>
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<td>✔</td>
<td>✔</td>
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<tr>
<td>Stress shift</td>
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<tr>
<td>Suffix allomorhism</td>
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<td>Vowel alternation</td>
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<tr>
<td>Vowel deletion</td>
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</table>

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Table 2 displays information about the type frequencies of the stems included in the experiment and about their productivity. In the first row corresponding to the Russian language, the first set of numbers in each column represents the results of the verb counts performed on the Grammatical Dictionary of the Russian Language (Zalizniak 1980) with approximately

\[\text{\textsuperscript{2}}\] The (\(\text{\textsuperscript{26}}\) and (\(\text{\textsuperscript{1}}\)) stems are the sub-classes of zero-suffixed stems, each of them has an idiosyncratic ("irregular") feature in the conjugational pattern.

\[\text{\textsuperscript{3}}\] This paper does not discuss stress shifts in the data. Unlike the other morphological processes, which can be predicted given the verb stem, stress shifts need to be lexically encoded. However, the pattern of stress shift within the paradigm is fixed.

\[\text{\textsuperscript{4}}\] Strictly speaking, the term "L2 input" in this case is inaccurate, since the assessment of L2 input frequencies included both what L1 learners heard and produced themselves.

\[\text{\textsuperscript{5}}\] The first figure corresponds to the number of verbs in the active vocabulary, and the second figure (in parentheses) to all the verbs from the active and passive vocabulary combined.

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<table>
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<tr>
<th>Verbs classes</th>
<th>(\text{\textsuperscript{26}})</th>
<th>(\text{\textsuperscript{21}})</th>
<th>(\text{\textsuperscript{2}})</th>
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<tr>
<td>Input to L2 learners type frequency</td>
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<tr>
<td>Input to L2 learners number of cases</td>
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Rules and Probabilities in L1 and L2 Processing of Russian Verbal Morphology

Experimental material

The material for Experiment 1 with native speakers of Russian consisted of 48 nonce verbs created by manipulating the initial segment of 48 real Russian verbs, which were used in Experiment 2 with American learners of Russian. These verbs belonged to 9 classes and sub-classes based on the one-stem verb system.

3 pairs of stems have a similar past tense and infinitives, but have different conjugational patterns in the non-past tense: -a/- and -e/-, -e/- and -e/-, and (ii) and -e/. The stem is unrecognizable in the past tense or infinitive because the "j" is truncated; therefore the speakers presented with the past tense or infinitive form of a novel verb need to "guess" the underlying stem to conjugate the verb in the non-past tense. Of the 6 stems, three belong to the high type frequency productive classes -a/-, -a/-, and -e/- (see Tables 1 and 2). The -a/- class has the highest type frequency of all the Russian verbs, and the conjunctural pattern for this class involves only the automatic consonant transition rule, which means the -a/- verbs have only two stem allomorphs, with and without the "j". The -a/- class, while also being productive, has much lower type frequency than the -a/- class. Otherwise, the conjunctural pattern is the same as for the -a/- class. It is important to note that in the large productive classes the only phonologically similar part, which is shared by all the verbs, is the vowel of the suffix.

The "matching" -a/- and -e/- classes, which do not have the "j" in their stems, both belong to small unproductive classes with consonant mutations and stress shifts contributing to a wider stem allomorphy. Generally speaking, non-automatic stem changes may have a different influence status than allomorphy, however, since all parts of the conjunctural pattern except for stress shift are derived by the rules for each class, and do not need to be lexicalized, these classes do not have to be termed as irregular. However, they are definitely more irregular, if we are to adopt a gradual parameter of irregularity, than the -a/- and -e/- classes. As we will see below, the -e/- class, which has exactly the same conjunctural pattern as the -e/- class, can be considered regular, since it is productive. Neither the -e/- nor the -e/- class form any similarity-based neighborhoods. Thus, in the generation of novel verb forms, one can expect the high-frequency productive and less complex -a/- and -e/- conjunctural patterns to be generalized to the small unproductive and more complex -a/- and -e/- classes.

The third high-frequency productive -e/- class has exactly the same conjunctural pattern as the -e/- class, and therefore, in terms of stem allomorphy, tends to be less regular than the previous two productive classes. At the same time, as a productive class, the -e/- class meets the dual-system criteria for regular rule-based inflection. Its "pair": the (ii)- subclass of the zero-suffixed verbs, is interesting in several respects. First, strictly speaking, there are two kinds of (ii)- verbs, with 2 stems, one of which is obsolete, behaving as any other zero-suffixed stem ending in a resonant, and the remaining 5 verbs organized in a neighborhood. The verbs in this neighborhood are phonologically similar, and all of them undergo the same stem changes before vocalic endings. Compare their infinitives and basic stems (see Table 3):

The 5 (ii)- verbs resemble the English irregular verb neighborhoods, because they share similar phonological features and idiosyncratic stem allomorphy. This means, that their conjunctural patterns can be expected to be extended to phonologically similar novel verbs by analogy. At the same time, as all the zero-suffixed stems ending in a "j", these verbs display a feature in their conjunctural pattern that makes them superficially similar to the -a/- and -e/- stems, notably, the presence of "j" before vocalic endings.

Compare:

-aj-: chit-ai ("to read"); chit-a/- + -a = chita/"I read"
-aj-: pit- ("to drink"); pit- + -a = pita/"I drink"

As opposed to:

-a/-: pit-ai ("to write"); pit-a/- + -a = pita (with the "s" mutating to "sh")

One can expect the high-frequency productive -e/- pattern to be generalized to the small unproductive (ii)- class based on the predictions both of the
single-system and dual-system approaches. The (i/-) conjugational pattern with the stem vowel deletion is expected to be generalized to phonologically similar verbs.

The next two stems included in the testing material, -ovu- and -uvnu-, have similar conjugational features — they show suffix alternations in the non-past tense: -ovu- alternates with -u-, and -uvnu- alternates with -uv-. For such stems, the past tense form contains sufficient morphological information (morphological cues) for the speakers to be able to identify the stems. However, these classes differ radically in their type frequencies: the -ovu- class has high type frequency, whereas the -uvnu- class has only three basic stems. The experiment tested whether the subjects actually pay attention to the morphological cues and produce the suffix alteration expected in these stems, and whether type frequency influences their processing.

The last stem, or more exactly, the subclass of zero-suffixed stems, (o)/(-), has only 5 verbs in it and a very special feature: alternation of the root vowel before consonantal endings in the past tense and the infinitive: "a" alternates with "y", which does not occur in any other verb stem. The verbs of this sub-class also resemble an English irregular verb neighborhood. This stem was included to test whether the presence of the vowel "y" in the stimulus verb form serves as a cue for the low type frequency (o)/(-) stems (see Table 4).

<table>
<thead>
<tr>
<th>Table 4. The (o)/(-) Sub-Class of Zero-Suffixed Stems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>kr1/-</td>
</tr>
<tr>
<td>ma/-</td>
</tr>
<tr>
<td>ri/-</td>
</tr>
<tr>
<td>tv/-</td>
</tr>
<tr>
<td>kmo/-</td>
</tr>
<tr>
<td>kru/-</td>
</tr>
</tbody>
</table>

Experiment 1: Generation of verbal inflection by Russian native speakers

27 adult native speakers of Russian took part in the experiment that involved the generation of the 1st person singular and 3rd person plural non-past tense forms of the verbs presented in the plural past tense form. All the verbs were embedded into simple carrying sentences, with the exchanges between the experimenter and the subject forming a question-dialogue. All the answers were recorded on audiotape, and then transcribed and analyzed.

Table 5: Distribution of Responses in Experiment 1 with Native Speakers of Russian

<table>
<thead>
<tr>
<th>Stimuli</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>-aj-</td>
<td>0.06</td>
</tr>
<tr>
<td>-eu-</td>
<td>0.11</td>
</tr>
<tr>
<td>-is-</td>
<td>0.08</td>
</tr>
<tr>
<td>-ovu-</td>
<td>0.11</td>
</tr>
<tr>
<td>-uvnu-</td>
<td>0.09</td>
</tr>
<tr>
<td>*yi/-</td>
<td>0.09</td>
</tr>
<tr>
<td>Other</td>
<td>0.09</td>
</tr>
</tbody>
</table>

If any event, the -aj- pattern is the best candidate for the default pattern, if we adopt that the vowel is part of the pattern. However, if the symbolic rule does not specify the vowel, and indeed, it cannot, since the default rule can be used with any vowel, not only the "aj" with varying degrees of probability, then we need to extend the default rule to the "Vowel" formulation. The Rule Competition Model not only predicts the high generalization rates for the -aj- pattern, but also the Free-Rider Effect for the relatively much lower-frequency -aj- pattern, if we are to assume that the actual rule "recover the 'i' before vocative endings / drop the 'i' before consonantal endings" works with more than one suffix vowel, in this case, the "a" and the "e".

In the last pair of stems, the -is- and the (i/-), the relationship between the type frequency and degree of regularity is reversed. The results for the -is- and (i/-) stems indicate that native speakers had major problems dealing with the
small unproductive (i)-stem, in half of the responses it was erroneously conjugated using the entire past-tense form including the past-tense inflection as the basic stem. At the same time, the (i) pattern was generalized to the -s verbs in 16.7% of responses, which is a non-negligible rate. Since the small unproductive (i)-subclass is organized as a neighborhood, if its pattern is generalized to novel verbs, this should be based on analogy. But this is not what we observe in the obtained results. First, the (i) pattern found in mono-syllabic verbs is generalized to disyllabic -s verbs that have no phonological resemblance to the (i)-verbs. And second, the generalization of the "Vowel+" pattern to the -s verbs did not fully reflect the (i)-conjugational pattern—native subjects ignored the vowel deletion part of the conjugational pattern. These two facts suggest that the generalization of the (i) pattern was not analogy-based, rather it was the "Vowel+" symbolic rule that was generalized.

While the extremely low identification and generalization rates for the (i)-stem are not surprising given its low type frequency, the results for the -i-stem require special attention. Indeed, the high-frequency productive -i- had identification and generalization rates much lower than the -aj- and -uj-stems. Only one third of the -aj- and -uj-verbs were conjugated using this pattern. The fact that the high-frequency productive -i-pattern has such low identification and generalization rates in a nonce verb generation task does not support the single-system approach. If generalizations were based on phonological associations, then the "i" vowel in the verb suffix would have been associated with the "Vowel+" pattern, but apparently the default "Vowel+" pattern was competing with analogy-based generalizations, and as a result neither pattern received high generalization rates. The fact that the small unproductive (i)-pattern used in a phonologically-organized neighborhood was generalized to the high-frequency productive phonologically open -i-class indicates that the mechanism of generalizations was rule-based, and not analogy-based. Another argument in favor of the rule-based mechanism is the fact that the (i)-pattern was not generalized in its entirety—as would have been expected in analogy-based processing—since the recovery of the "i" took place without the expected root vowel deletion. Overall, the results for the "paired" -i- and (i)-stems demonstrate the strength of the default in novel verb processing.12

The implications of the data on the -i- and (i)- verb processing for the dual-system approach are less obvious because the dual-system approach is not very clear on the possibility of having several regular patterns for an inflectional paradigm in languages other than English. However, these data seem to create problems for either position on this issue. Thus, the claim that regularity is associated with productivity places the -i-pattern into the regular category, and therefore predicts that it should be generalized in novel verb processing. The generalization rate for the -i- stem is too low to support this claim. The dual-system position, which associates default and regular processing, would categorize the -i-pattern as irregular, and therefore expect the (i)-pattern to be generalized to the -s verbs. The low rates of such generalizations do not support this prediction either. Apparently however, the obtained results support the rule-based generalization as opposed to analogy-based one, exactly because the "recover the "i"" rule seems to be the basis for generalizations, regardless of the suffix vowel. At the same time, the frequency of such generalizations depends on the suffix vowel, and in this sense the rule-based generalization is sensitive to input frequencies. This ultimately means that the Rule Competition Model has a better fit to the data.

The next high-frequency productive -ovu-stem is different from the previously discussed "paired" stems in two respects. First, it exhibits the suffix alternation feature rare in the Russian conjugational system—"i" in the non-past tense the -ovu-suffix alternates with -oj-, and second, unlike the "paired" suffixes, the -ovu-suffix, which is present in the infinitive and past tense, can serve as a morphological cue to the conjugational pattern. The -ovu-stem was recognized to almost half of the answers (47.2%), while in 40.4% the morphological cue was ignored, and the verb was conjugated as an -oj- verb, without suffix alternation and using the "Vowel+" pattern. The relatively low rate of stem recognition for the high-frequency productive -ovu-class again raises the issue of regularity, as this class meets the standards of the dual-system approach for regularity, but definitely belongs to non-default conjugation. Based on the rates of stem recognition obtained for this class, one can claim that it was in competition with the default -oj-class, and the morphological cue had limited use in native processing.

The -ovu-stem has the same properties as the -ovu-stem, as it also has suffix alternation, the -ovu-alternating with -oj-, and the suffix can serve as a morphological cue to the conjugational pattern. However, unlike the -ovu-class, the -ovu-class has only 3 basic stems in it, and one cannot expect it to have high generalization rates. And indeed, not only does this pattern have low generalization rates, it was recognized only in 21.8% of responses, while in 61.1% of responses the -ovu-verbs were conjugated using the -oj-pattern. These low rates obtained for the low-frequency unproductive -ovu-class compared to the -ovu-class are in conformity with the predictions of the single- and dual-system approaches, as well as of the Rule Competition Model. We have made a special effort to differentiate between rule-based and analogy-based generalizations. The fact that the high-frequency productive -ovu-pattern was used only in half of the responses to the novel -ovu-verbs indicates that, indeed, phonological associations had a limited role in the processing of this stem. Obviously, the disyllabic -ovu-cue provides a wider basis for establishing associations than the vowel "i" from the unrecoverable -aj-stem. Despite this, the rates of stem recognition were significantly lower for the -ovu-stem than for the -oj-stem.

12 I am deeply indebted to Amy Weisberg from the University of Maryland for help with the argumentation of this position.
And finally, the last stem (v), the sub-class of the non-suffixed verbs with low type frequency and an idiosyncratic feature in the conjunctival pattern, root vowel alternation, was practically not recognized as such, but remarkably, almost half of the responses to this stem conjugated it using the non-existing *(v)-pattern illegal in Russian. While the fact that the low type frequency pattern with a minor rule was poorly recognized does not come as a surprise, the creation of the illegal *(v)-pattern indicates that the default "Vowel+v" pattern is indeed rule-based, and is not associated with individual suffix vowels present in the infinitive rhymes.

Despite the fact that the study did not support the major claims of the single- and dual-system approaches, it documented the role of default processing, which had the highest generalization rates. An additional observation on the properties of default inflection in Russian verbal processing is in order: the default pattern has the highest type frequency, an open schema, but also the most regular inflection, which refers to the absence of stem allomorphy (outside automatic truncation) or lexicalized processes.

To summarize the discussion, the stem recognition and generalization data collected in the experiment on nonce verb processing by adult native speakers show the effects of type frequency and at the same time the pattern of responses indicates that morphological processing is rule-based and not analogy-based. The second finding of this study is that type frequency, or statistical probability that a particular pattern, including the default pattern, is used for the verbs with particular suffix vowels, influences the frequency of generalizations. In other words, the choice of the pattern appears to be based not only on the frequency of the pattern itself, but also on its frequency of use for the class of verbs with a particular suffix vowel in the rhyme. Thus, the study has demonstrated the role of input frequency in symbolic rule application, an effect incompatible either with the single- or dual-system approach. At the same time, the results are compatible with the principles inherent to Yang’s Rule Competition Model including the Free-Rider Effect. However, there is a major difference between the Rule Competition Model and the effect demonstrated in the present study. Namely, the Russian data indicate that there is an interaction of statistical probabilities and symbolic rule application in a stabilized adult native linguistic system.

**Experiment 2: L2 generation of Russian verbal morphology and the Rule Competition Model (Yang 2002)**

Since we have argued above that native processing is rule-governed rather than analogy-based and it is influenced by the frequency of the rule, we will be looking for the same features in L2 processing. The results should confirm or disprove the hypothesis that the generalization rate of the conjunctival pattern depends on its frequency of use in the input. At the same time, we will try to find evidence in the obtained data that would point to the fact that L2 learners rely on rule-based as opposed to analogy-based processing mechanisms.

But we will keep in mind a fundamental difference between native and L2 morphological processing, namely, the fact that for native speakers the probability of a certain inflectional pattern for an existing word is close to either 100% or 0%, depending on whether it is correct or not. At the same time, for L2 learners these probabilities will not be set, and it will fluctuate between 100% and 0%. In this respect, L2 processing is comparable to child L1 processing.

**Experimental procedure**

15 volunteer students, who have completed one year of intensive Russian at the University of Maryland, took part in Experiment 2. The experimental procedure was exactly the same as in Experiment 1 (see above).

**Discussion**

Table 6 contains two sets of data on input frequencies to our L2 learners, type frequency and number of uses, as well as the collapsed data on their rates of stem recognition.

Several features of their answers deserve special attention:

1. Quantitative differences between the verb classes are less salient in the L2 input. This relatively small difference is the most apparent for the -ej- and -eu- classes.

2. The -ej- stem is not represented in the L2 active vocabulary.

3. The -ev/ stem is less represented than the -eu- stem in L2 input, while in native input the -ev/ stem is higher in frequency than the -eu- stem.

### Table 6: Input Frequencies and Rates of Stem Recognition and Generalization in L2 Speakers

<table>
<thead>
<tr>
<th>Conjugational Pattern</th>
<th>Input to L2 Learners</th>
<th>Percent Stem Recognition</th>
<th>Percent Generalization to <em>Prefer</em> Stems</th>
<th>Percent Response to All Stems</th>
</tr>
</thead>
<tbody>
<tr>
<td>-ej-</td>
<td>55</td>
<td>79.0</td>
<td>66.0</td>
<td>37.5</td>
</tr>
<tr>
<td>-e-</td>
<td>24</td>
<td>22.0</td>
<td>12.0</td>
<td>12.8</td>
</tr>
<tr>
<td>-ej-</td>
<td>12</td>
<td>56.0</td>
<td>38.0</td>
<td>9.9</td>
</tr>
<tr>
<td>-e-</td>
<td>8</td>
<td>48.6</td>
<td>9.3</td>
<td>3.9</td>
</tr>
<tr>
<td>-ej-</td>
<td>3</td>
<td>55.0</td>
<td>7.2</td>
<td>9.8</td>
</tr>
<tr>
<td>-e-</td>
<td>32</td>
<td>63.0</td>
<td>22.0</td>
<td>8.5</td>
</tr>
<tr>
<td>-e-</td>
<td>13</td>
<td>35.5</td>
<td>16.1</td>
<td>5.3</td>
</tr>
<tr>
<td>-e-</td>
<td>2</td>
<td>27.3</td>
<td>3.9</td>
<td>0.4</td>
</tr>
<tr>
<td>-ej-</td>
<td>2</td>
<td>15.8</td>
<td>1.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>16.1</td>
<td>16.1</td>
<td>16.1</td>
</tr>
</tbody>
</table>

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13 This measure exactly corresponds to the frequency of use, the measure used by Yang (2007) to assess the input to children acquiring English as their L1.
Given the leveling of differences in class size to the non-native input, one could expect less generalizations of high type frequency classes to small classes and less reliance on the default pattern in L2 processing.

The results obtained for beginning adult American learners of Russian (see Table 6) were similar to the ones obtained for native Russians in several respects:

1. In the "pured" -aj/-ar stems, the "Vowel+I" pattern is dominant.
2. The rates of stem recognition for the conjugational patterns involving suffix alternation -ovu- and -ovu- are very low compared to the rates obtained for the "Vowel+I" classes.
3. The (o)y- stem was practically not recognized, and 30% of responses to this stem used the illegal *(o)y- pattern.

At the same time, a closer comparison of the native and L2 sets of data revealed the differences, which according to the Z-test are significant at the 0.05 confidence level for all the stems, except for the (o)y- stem. These differences can be summarized as follows:

1. Several aspects of L2 processing are less dominated by the default pattern: First, L2 stem recognition rates for the -aj- and -ey- stems are lower and for the -a- and -e- stems higher than in native speakers. Second, the high rates of stem recognition for the -e- stem show that L2 speakers were not influenced by the default in their choice of the "Vowel+o" pattern as were the native speakers. And finally, the rates of the use of the *(o)y- pattern are lower in L2 speakers. We hypothesize that the reduced role of the default pattern is due to the less pronounced differences between class sizes and the resulting diminished role of default in L2 input.

2. Other aspects show a strong Free-Rider Effect that manifested itself in the verbs with the "wrong" rhyme vowels.

a) The relatively high rates of stem recognition for the (o)y- stem indicate that L2 learners were not influenced by statistical probabilities than native speakers, as they tended more to ignore the fact that the (o)y- pattern is extremely rare in Russian.

b) The most remarkable result is that L2 learners used the -ej- pattern in response to the -ej- verbs despite the fact that there were no -ej- verbs in their active vocabulary. All this indicates that L2 learners do not rely on statistical probabilities exactly the way native speakers do. As a result, L2 learners use the default pattern with the suffix vowel that they have not encountered with the default pattern.

3. Morphological cues have a limited use in L2 processing. Whereas native speakers were much better at recognizing the -ovu- pattern than the -ovu- pattern, L2 learners perform poorly on both of them.

Therefore, we have observed two important features of L2 processing. First, the leveling of type frequencies in the reduced L2 input leads to the weakening of the role of default. And second, L2 processing is characterized by insufficient control of the probability that a conjugational pattern will be used with a particular rhyme vowel, which leads to a strong Free-Rider Effect.

If we apply the same arguments to the L2 data as the ones we applied above to the L1 data, then we need to admit that L2 processing relied on rules rather than on analogies. An additional argument in favor of rule-based processing is the fact that beginning learners know so few L2 verbs that it is less likely that they would be influenced by phonological similarity to other verbs. Another argument in favor of discrete rules as opposed to phonological associations is the high rate of missed mutations both in native and L2 processing (see Gor, Chernigovskaya 2003a). If the non-past and past-tense forms of the verb, and also different forms of the verb in the non-past-tense paradigm were connected to each other through phonological associations, consonant mutations should be part of these connections along with other parameters of the conjugational paradigm, such as the choice of the thematic vowel in the inflections, which in Russian differentiates between 1st and 2nd conjugation. However, it appears that both native and L2 speakers single out the consonant mutation parameter and often omit it in novel verb processing. At the same time, their behavior vis-a-vis the choice of the thematic vowel is radically different. While native speakers practically always maintain the conjugation type with the overall conjugational pattern, L2 speakers make errors in the choice of the conjugation type. Their typical error is the incorrect assignment of 2nd conjugation -i- and -e- verbs to 1st conjugation, with the 2nd conjugation being more common in Russian.

The Experiment 2 with adult American learners of Russian explored the applicability of the Rule Competition Model (Yang 2002) to L2 acquisition. As a matter of fact, SLA theory devoted a lot of attention to the issue of L2 variability. One of the most notable features of L2 performance is precisely the fact that an individual speaker can use different linguistic patterns, corresponding to native language and deviating from it, more or less interchangeably. Some of this variability is systematic, and depends on linguistic factors such as the context, but there is an important part of variability that cannot be accounted for by any observable factor. This part is considered to represent free variation in L2 linguistic processing. It is possible that the L2 speaker, the same way as the child acquiring L1 (ibid.), has several grammars simultaneously at his/her disposal, and these grammars compete with the target one gradually "pushing out" the non-target ones? While this claim has not been formulated in computational terms in L2 theory, research on developmental stages and sequences in L2 acquisition has entertained exactly the same ideas. Experiment 2 tested whether L2 learners have a variational system of inflectional rules, which is shaped by the input frequencies to L2 learner. In this understanding, conjugational patterns have weights, which reflect their-frequency of use in the input to L2 learner. And indeed, the experimental data support this hypothesis. At the same time, the Rules and Probabilities mechanism that we have observed in native adults is not fully developed in L2 learners.
Conclusions: The Rules and Probabilities Model in the Processing of Russian Inflectional Morphology

The observed features of novel verb generation prompt several hypotheses about the mechanisms governing verbal processing in Russian. There are several symbolic rules operating in Russian verb conjugation, the main ones being the "Vowel+Vowel+" and "Vowel+Vowel+" rules. These rules are probabilistically associated with the vowel of the verbal classifier in the infinitive and past tense, with the "Vowel+" of the suffix is truncated. In this sense, there is rule competition in novel verb processing. The "Vowel+" rule is the default rule. Since real verb processing in adult native speakers is virtually error-free, this indicates that there is some system of tagging in addition to the potentially available input-based mechanism of statistical probabilities. The important thing is that the patterns involved in Russian verb processing are indeed symbolic rule-based, and do not rely completely on analog-based phonological associations. The concept of the local default (discussed in Ullman 2000) receives a different interpretation within this framework: the default rule is general enough, but it has different weights depending on the frequency of use of the default pattern with specific vowels in the verbal classifier.

It is true that the default "Vowel+Vowel+" pattern has the highest type frequency and a very open lexicon, in the sense that it is used with all the Russian vowels. However, the "Vowel+Vowel+" pattern comes close to it in type frequency and has a similar distribution. This means that the assignment of default status in Russian verbal morphology probably does not always have some additional features of the two conjunctural patterns in question. Notably, the "Vowel+Vowel+" pattern is associated with stem changes, primarily including consonant mutations and stress shifts. Moreover, stress shifts are unpredictable within the conjunctural system of Russian, and therefore need to be lexically encoded.

Finally, the reanalysis of the L1 and L2 data on Russian novel verb generation lends support to the Rules and Probabilities Model outlined in this paper, which extends the idea that linguistic rules are used probabilistically from child L1 to SLA and adult native processing.

References


* The "Vowel+Vowel" pattern has a controversial status in the phonological system of Russian, and is not considered to be an independent phoneme in many descriptions.


