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Paradigm structure: evidence from Russian suffix shift

Abstract

In this article we advance the Paradigm Structure Hypothesis, arguing that paradigms are radial categories with internal structure primarily motivated by semantic relationships of markedness and prototypicality. It is possible to construct an expected structure for a verbal paradigm, facilitating an empirical test for our hypothesis. Data tracking an on-going morphological change in Russian documents the distribution of conservative vs. innovative forms across the cells of the verbal paradigm. A logistic regression model that takes into account the sources of variation (the frequencies of individual verbs and paradigm slots, and individual verb preferences) shows that the language change is implemented differently across the paradigm forms, confirming the expected structure. We conclude that the diachronic change analyzed in this article gives evidence for the structure of paradigms modeled on the radial category.

Key words: paradigm, radial category, language change, prototypicality

1. Introduction

This article analyzes the specific details of an on-going language change, a suffix shift among Russian verbs, with an eye toward the theoretical implications this change has for the structure of inflectional paradigms. Section 2 presents the facts of the Russian suffix shift, showing which forms in the paradigm it affects and what changes in the grammar it entails. Section 3 is devoted to issues surrounding the paradigm and its structure. Theoretical arguments concerning the status of the paradigm come first (3.1), followed by a discussion of whether the paradigm has internal structure (3.2). Assuming that the paradigm has both status and structure, we offer the radial category as a likely model for hierarchically-structured paradigms (3.3). This section concludes with an expected structure for the Russian verbal paradigm based on rankings of markedness and prototypicality. This expected structure provides a concrete test case for the Paradigm Structure Hypothesis proposed in Section 4. A statistical analysis of data documenting the Russian suffix shift confirms the expected structure and thus the hypothesis (4.1). In Section 5 we evaluate the possibility that the effects we find can be attributed to frequency. Conclusions are drawn in Section 6.

2. Russian suffix shift

The Russian verbal suffix shift provides us with the opportunity to witness a language change in progress and analyze its mechanisms in detail. This change involves a shift from a non-productive verbal suffix to a productive one, yielding regularization in the grammar. Though this change is well-known, no previous attempt has been made to investigate its distribution across the paradigm. Data culled from the Russian National

Corpus (henceforth RNC, at www.ruscorpora.ru) reveal that the Russian suffix shift is progressing through the verbal paradigm in an uneven fashion.¹

With few exceptions, Russian verbs are suffixed.² The Russian suffix shift involves thirty-seven verbs that are in the process of shifting from the non-productive *-a* suffix to the productive *-aj* suffix. Table 1 illustrates this change.

	<i>-a</i> suffix	<i>-aj</i> suffix
1sg	kapl ^ɪ u	kapaju
2sg	kapl ^ɪ oʃ	kapajoʃ
3sg	kapl ^ɪ ot	kapajot
1pl	kapl ^ɪ om	kapajom
2pl	kapl ^ɪ ot ^ɪ e	kapajot ^ɪ e
3pl	kapl ^ɪ ut	kapajut
Present Active Participle	kapl ^ɪ uʃ ^ɪ ij	kapajuʃ ^ɪ ij
Imperative	kapl ^ɪ i(t ^ɪ e)	kapaj(t ^ɪ e)
Gerund	kapl ^ɪ a	kapaja
Infinitive	kapat ^ɪ	kapat ^ɪ
Past masc sg	kapal	kapal
Past fem sg	kapala	kapala
Past neut sg	kapalo	kapalo
Past pl	kapal ^ɪ i	kapal ^ɪ i

Table 1: Forms of *kapat* ‘drip’ with the original *-a* suffix and the innovative *-aj* suffix

There are two observations to be made from Table 1. The first observation is that the forms of the past tense and infinitive are identical for the two suffixes. The homophony of past tense and infinitive forms likely serves as the motive for an abductive change (Andersen 1973), whereby the productive suffix is replacing the non-productive one. This change can thus be compared to the change in English of verbs from the strong to the weak pattern.³ The second observation is that the suffix shift eliminates a consonant alternation. Verbs that are undergoing suffix shift have a consonant alternation in their *-a* suffixed forms that is absent in their *-aj* suffixed replacements.⁴ In the case of *kapat'*, the consonant alternation can be seen throughout all Non-Past forms, plus the Present Active Participle, Imperative, and Gerund, where /p/ alternates with /pɫ/ in the *-a* suffixed forms, but does not alternate in the *-aj* suffixed forms (where all forms contain only /p/). The Russian suffix shift therefore

¹The data was collected from the RNC in April-July 2006. We gratefully acknowledge the assistance of Hyug Ahn and John Korba in extracting these data.

²The exceptions involve a handful of non-productive conjugation types. Townsend (1975: 98-99) gives an inventory of the non-suffixed verbal stems in Russian, totaling 67, which is meager in comparison with the estimated 20,000 verbal stems (Divjak 2004) in the language.

³However, unlike English, where there are some examples of verbs shifting in the opposite direction, as in the case of *sneak/sneaked* shifting to *sneak/snuck* (cf. Bybee and Slobin 1982), the Russian suffix shift is unidirectional.

⁴In addition to /p/ ~ /pⁱ/, verbs undergoing suffix shift show the following alternations: /m/ ~ /mⁱ/, /b/ ~ /bⁱ/, /k/ ~ /t^k/, /g/ ~ /z^g/, /x/ ~ /ʂ/, /t/ ~ /t^j/, /d/ ~ /z^d/, /sk/ ~ /ʃ/, /st/ ~ /ʃ/. This simplification is discussed in detail in Nesset (2008).

entails regularization and simplification of the grammar because it moves verbs from a non-productive to a productive class and removes a morphophonemic alternation.

The Russian suffix shift is well attested in reference works such as Zaliznjak (1977) and Švedova et al. (1980) and has been examined from the perspectives of language acquisition, psycholinguistics, stylistic variation, sociolinguistics and dialectology (cf. e.g. Andersen 1980, Gagarina 2003, Gor & Chernigovskaya 2001, 2003a-c, Kiebzak-Mandera et al. 1997, Krysin (ed.) 1974, Tkachenko & Chernigovskaya 2006 and references therein). However, there has not been any study that examines differences in the realization of this change across forms of the verbal paradigm. As reflected in Table 1, the Russian suffix shift affects the Non-Past, Present Active Participle, Imperative, and Gerund forms. In section 4 we present an empirical study of how the suffix shift is progressing through these forms of the verbal paradigm. Before turning to the data and analysis, however, we need to discuss the notion of the paradigm and its theoretical implications, which is the topic of section 3.

3. The paradigm and its structure

A number of theoretical questions surrounding the concept of the paradigm remain open, such as: Do paradigms have a theoretical status? If paradigms do have such a status, do they have internal structure? If paradigms have internal structure, what kind of structure do they have? What factors motivate the internal structure of paradigms? In this section we briefly review the theoretical arguments that have been made concerning the existence and structuring of paradigms.⁵ If we assume that paradigms do exist and do have structure, the next step is to propose what sort of structure the paradigm should have. It should then be possible to suggest a structure for the Russian verbal paradigm that is relevant for our data on the Russian suffix shift. This section follows this line of reasoning in order to establish a concrete hypothesis that can be tested against our data.

3.1 Does the paradigm have theoretical status?

Let us offer an informal definition of paradigm as “a set of inflected forms that share a single stem”.⁶ Although few theoretical terms have a longer history in linguistics, there is considerable disagreement about the status of the inflectional paradigm. Some linguistic theories deny the paradigm any status whatsoever, and among theories that accept the paradigm there are opposing views concerning whether paradigms are unstructured inventories or coherent networks.

Paradigms are a hallmark of our legacy from the classical grammarians of Greece and Rome. Plank (1990b: 161) notes that “the earliest extant grammatical texts are paradigms” that date from about 1600 BC and present the inflected forms of Sumerian. Robins (1979: 25) characterizes the central role of paradigms in this

⁵Since we offer here a brief summary, we do not claim to include all details of various proposals that have been made concerning the paradigm. Our purpose is to highlight the most significant arguments that are relevant to the analysis in section 4.

⁶This definition does not accommodate suppletion, but suppletion is not relevant to the data explored in the present article.

tradition as follows: “The framework of grammatical description in western antiquity was the word and paradigm model”. The listing of paradigms is a standard feature of reference grammars to this day.

In contemporary linguistics, however, the status of the paradigm has been challenged and paradigmatic relations have been neglected (van Marle 1985:15ff.). Morpheme-based approaches to morphology dispensed with the paradigm altogether. Such frameworks include classical Item and Arrangement (IA) and Item and Process (IP; both described in Hockett 1958), as well as more recent approaches such as Distributed Morphology (Halle & Marantz 1993, Noyer URL). These frameworks propose a lexicon that contains morphemes and a grammar that specifies rules for combining those morphemes, obviating the need for the paradigm. The paradigm is accordingly regarded as an epiphenomenon lacking status as a theoretical object.

The paradigm has not, however, been unanimously rejected. Morphological models such as Word and Paradigm (Matthews 1972 & 1991, Anderson 1992) and Paradigm Function Morphology (Stump 2001) argue in favor of the paradigm. Stump (2001: 32) claims that “paradigms play a central role in the definition of a language’s inflectional morphology” and that “paradigms are not the epiphenomenon that they are often assumed to be in other theories, but constitute a central principle of morphological organization”. Fundamental to Stump’s framework are paradigm functions that relate a root to a cell in a paradigm.

The morpheme-based approaches and the word-based approaches both proceed from a set of theoretical assumptions to build their models, differing radically in whether they choose to deny or recognize the paradigm. An alternative way to probe the theoretical value of the paradigm is by asking whether there are linguistically significant generalizations that cannot be stated without referring to the paradigm. If this is the case, it follows that the paradigm has theoretical status. Both the Paradigm Economy Principle (Carstairs 1987) and the No Blur Principle (Carstairs-McCarthy 1994) have featured generalizations that support the recognition of relationships between inflectional classes. These principles provide at least indirect evidence for the paradigm since inflectional classes rely on the existence of paradigms of individual lexical items.⁷

Another kind of evidence in favor of the paradigm is syncretism. If the notion of paradigm enables us to state generalizations about syncretism, we have an argument for the paradigm as more than an epiphenomenon. McCreight and Chvany (1991), following Jakobson’s (1958) lead, argue that geometrical representations of paradigms facilitate more insightful descriptions of syncretism than syntactic features. For somewhat different approaches, which also concern geometrical representations of paradigms, see Plank (1990b) and Trosterud (2006).

Additional evidence for the psychological reality of paradigms comes from experimental linguistics. Milin et al. (2008) report on a psycholinguistic experiment with Serbian nouns showing that complexity of paradigms and inflectional classes

⁷Note that Müller (2007) has criticized both Paradigm Function Morphology and the Paradigm Economy Principle, claiming that they overstate the importance of the paradigm. Full discussion of this debate is beyond the scope of this article.

yielded longer response times. Milin et al. (2008:21) conclude that their results “support the theoretical concepts of paradigms and inflectional classes”.

Our aim is to continue the line of reasoning that presents arguments in favor of the paradigm. In section 4 we present empirical evidence that cannot be explained without reference to the paradigm. If we accept the paradigm as a theoretically significant entity, the question arises as to whether the paradigm has structure.

3.2 Does the paradigm have structure?

The null hypothesis is that the paradigm has no structure, being an unordered list of equiprobable items. Many modern theories take the null hypothesis for granted. A prominent recent example is McCarthy’s (2005) theory of Optimal Paradigms, which treats paradigms as unstructured entities where the same symmetrical relationships hold among the members so that no form enjoys a privileged position.

The notion of structured paradigms has a long tradition and continues to enjoy support among a variety of scholars. Bybee (1985: 49) and Karlsson (1985: 137) both provide detailed criticisms of the assumption that a paradigm has no structure, and their arguments are backed up by empirical evidence. In traditional grammars, certain items were recognized to have privileged status as leading or “base” forms from which other items in a paradigm are formed. This asymmetric relationship implies that the paradigm has a structure in which certain forms play a more central role. Matthews’ original version of the Word and Paradigm Model lacked formal mechanisms that could accommodate paradigm structure. However, Matthews (1972:86 et passim; cf. also Morin 1990) himself was aware of what he calls “parasitic formations”, i.e. relationships within a paradigm where one stem seems to be derived from a stem of supposedly identical status.⁸ In later versions of the model, Matthews (1991:201) invokes “metarules”, which are closely related to the “rules of referral” in Stump’s (1993, 2001) Paradigm Function Morphology. Both metarules and rules of referral involve relationships among certain forms of a paradigm, and thus imply that inflectional paradigms have structure. Paradigms as structured sets are pivotal in Bybee’s (1985) and Wurzel’s (1984, 1989) approaches to inflection. Bybee (1985:50ff.) discusses asymmetrical “basic-derived relations” holding among the members of a paradigm that resemble the implicational relationships investigated in Wurzel (1984:116-124 and 1989:112-121). In these approaches, paradigms are structured networks in the sense that the members have different statuses because asymmetrical relationships hold between them. According to Bybee (1985: 57f.) a “basic” member of a paradigm has a high degree of “autonomy”, which is the product of three factors, viz. semantics, frequency and irregularity.⁹ Plank (1990a: 35) likewise analyzes paradigms as structured sets, concluding that “paradigms must be recognized to be more than mere unstructured collections of labeled forms”. As important factors for paradigm structure, Plank (ibid.) mentions “the ordering and grouping of terms realizing inflectional categories, the hierarchical ranking of

⁸We will return to the phenomenon of parasitic formations in section 4.1. Similar paradigmatic relations appear to play a crucial role in derivational morphology as well, as argued by Booij (1997).

⁹Taking Bybee’s autonomy as his point of departure, Enger (2004) discusses paradigm structure in Germanic, Romance and Slavic in terms of his Stem Alternation Constraint for non-affixal inflection.

categories thus realized, the markedness evaluation of paradigmatic oppositions, and the singling out of one or more paradigm slots as formally more characteristic than the others.”

The studies reviewed in this section suggest that paradigms have internal structure. The next step is to explore what kind of structure we find in paradigms, how this structure is organized and motivated.

3.3 Paradigm structure as modeled by the radial category

We propose that paradigm structure can be modeled using one of the cornerstones of cognitive linguistics, namely the radial category. In a radial category, membership is defined in terms of an element’s similarity to a central member or subcategory – the prototype. In other words, radial categories are structured around one or several prototypes that are involved in asymmetrical relationships with peripheral members of the category. We suggest that analyzing inflectional paradigms as radial categories has several advantages.

The first advantage pertains to cognitive science. Prototypes and radial categories have been applied in psychology (cf. Rosch 1973, 1978), and appear to parallel the neural structure of the brain (Feldman 2006). Since the radial category emerges from general principles of cognition, the radial category offers an explanatory account of paradigm structure that eliminates the need to invoke any additional mechanisms that would be valid only for language.

A second advantage is that radial categories have been applied successfully in a variety of areas of linguistics (see particularly Lakoff 1987, Geeraerts 1995, Croft & Cruse 2004, and Lewandowska-Tomaszczyk 2007). The radial category provides conceptual unification across subdisciplines of linguistics, and thus enables us to relate paradigm structure directly to findings in e.g. syntax and phonology.

As a third point, we would like to mention that the radial category accounts for the markedness effects observed in paradigms (Andersen 1989: 37-8). The radial category has an internal structure based on the asymmetrical relationship between the central (unmarked) prototype and (marked) peripheral members. This structure comports with the known phenomena of markedness, such as universal ordering and productivity patterns, Brøndahl’s Principle of Compensation, the allo-eme relationship and neutralization, as well as markedness reversal. Universal ordering patterns result from the fact that the internal structure of a radial category is dependent upon the unmarked prototype and category members related to it. For the category to exist, the prototype must be present and a peripheral member is dependent on the prior existence of the prototype and any intervening members. Brøndahl’s Principle finds more differentiation among unmarked members than among marked members of a relationship. This Principle is a natural byproduct of the privileged position of the unmarked prototype, which has the densest set of relationships to other members, whereas the marked periphery bears a high cost of contextualization, restricting density of expansion. The relative cost of contextualization at the periphery yields the symptomatic allo-eme relationship, where marked allophones and allomorphs exist only in specific contexts in relation to the unmarked members of the relationship that appear in the zero context of neutralization. Janda (1995) details these parallels and

illustrates the role of radial categories in six case studies of markedness alignment (aka markedness reversal).

Last but not least, radial categories and prototypes have proven fruitful in morphological analysis, as observed *inter alia* by Bybee & Moder (1983), Janda (1993) and Dabrowska (1997), and yield precisely the type of structured network that has been proposed for paradigms by Bybee (1985) and Wurzel (1984 and 1989). Karlsson (1985, 1986) observed a skewed distribution of Finnish paradigm forms in corpus data and concluded that paradigms must be structured. Because he found a correlation between semantic classes of nouns and the frequency profiles of their paradigms, Karlsson further deduced that meaning properties motivate paradigm structure and that the paradigm is dominated by a few stereotypic forms that are the “morphological analogues of the prototypes in Rosch’s theory of word meaning” (Karlsson 1985: 150). Arppe (2005) and Janda & Solovyev (forthcoming) have confirmed the connection between meaning and the frequency distribution of paradigm forms in their studies of synonymy. These studies support the notion that a paradigm may be structured as a radial category and that this structure can be probed empirically.

The purpose of this article is not to prove or disprove the validity of radial categories, but to suggest that radial categories offer a good fit for the phenomenon we observe in our data. If our interpretation is correct, it has important implications for the paradigm, because we can identify the type of structure paradigms have and make a connection between paradigm structure and other types of structure that are pervasive in language and in cognition.

3.4 Paradigm structure and the Russian verbal paradigm

Studies of language change, language typology and psycholinguistics indicate that paradigms have a hierarchical structure and suggest how this structure is arranged. We will restrict this discussion to a sample of works that give evidence of structure within verbal paradigms, yielding a ranking of the categories that are investigated in the present paper.

Psycholinguistic experiments such as those reported in Bybee and Pardo (1982) and Bybee (1985: 66ff.) reveal asymmetric inference patterns. Subjects were more likely to use a mid vowel in a past tense form of a nonce verb if they had already heard a past tense form with such a vowel, whereas a mid vowel in the infinitive did not have as strong an impact. Bybee (1985: 67) states that “[T]his is support, then, for the hypothesis that there are different degrees of relatedness among forms, and that semantic relatedness determines the formal structure of members of a paradigm.” On a more abstract level, this finding suggests that finite verb forms are more prototypical than non-finite forms, since inferences are more likely to be based on the former and the direction of inference in a radial category is from the prototype to the periphery (Rosch 1975 & 1981). Typological evidence supports a distinction between finite as prototypical vs. non-finite as non-prototypical, since there are languages in which verbs lack infinitives altogether (Joseph 1983). The indicative is likewise the prototypical mood, insofar as it represents the simplest relationship of a situation to reality. Conditionals are more marked since they depict a situation as outside actual reality. Imperatives are about getting people to do things. As pointed

out by Nessel (1998:168), this means that the speaker wants something that is outside actual reality to become part of actual reality. Note that whereas verbs rarely lack indicative forms, some verbs (for example modal verbs, and in some languages verbs of perception) regularly lack imperative forms. Joseph (1983: 24, 110-113) argues that imperatives should be treated as non-finite on the grounds of reduced person opposition and clitic placement.

A cross-linguistic study of zero expression among indicative verb forms reported by Bybee (1985: 52ff.) shows that typologically zero expression is by far more common for third person than for first or second person. This finding suggests that the third person, as the unmarked form, is more prototypical than first and second person. This distinction is also supported by Lyons' (1977: 638) observation that the third person is unmarked because it "is negatively defined with respect to 'first person' and 'second person': it does not correlate with any positive participant role." Zwicky (1977: 718) corroborates this markedness designation, claiming that third person is maximally unmarked, since it refers to what is "left over" when the participants in the speech situation (first and second person) have been referred to.

Cross-linguistically singular is unmarked, and therefore prototypical, in relation to plural. This relationship finds support from Janda (1995) on semantic grounds, from Corbett (2000) on typological grounds, and from Lyashevskaya (2004) on the grounds of morphological and syntactic evidence.

Taken together, the various pieces of evidence cited in this subsection suggest the following distinctions in terms of prototypicality (where ">" means that the category to the left is more prototypical than the category to the right):

- finite > non-finite
- indicative > non-indicative
- third person > first and second person
- singular > plural.

Collectively these distinctions establish the following expected hierarchy for the forms in the Russian verbal paradigm that are undergoing the suffix shift:

3sg > 3pl > 1&2person > imperative > gerund/participle.

The remainder of this article takes this hierarchy as its point of departure.

4. The Paradigm Structure Hypothesis

Section 3 gave an overview of a variety of theoretical and empirical studies that support paradigm structure and established an expected hierarchical structure for the Russian verbal paradigm given a variety of types of independent evidence. In this section we state our hypothesis. We then give an operational description of what findings in the Russian suffix shift data would support or refute the hypothesis. The findings are then presented and analyzed.

Paradigm Structure Hypothesis: Paradigms are radial categories with prototypical and peripheral members.

This hypothesis has direct consequences for language change since we expect language change to progress from peripheral to prototypical forms. Thus a diachronic

change like the Russian suffix shift should affect the peripheral forms more than the prototypical forms.

The null hypothesis, by contrast, assumes that all forms of a paradigm have equal status and therefore should be affected by diachronic change to the same extent. If paradigms were unordered lists, there would be no reason for different forms in a paradigm to behave differently when undergoing a language change.

The Paradigm Structure Hypothesis builds on the logic that a change will begin at the periphery of a radial category, which will show earlier and stronger evidence of the change than the core. Analogical leveling tends to eliminate items that are peripheral. The histories of languages show ample evidence of changes that begin at or are limited to the peripheries of classes; here we cite a few examples from the history of the Slavic languages.¹⁰ In the history of Slavic, the dual number was peripheral in relation to singular and plural, and the dual became more and more restricted to use with paired objects, with its paradigm reduced to a few syncretic forms. Ultimately the dual number was lost in all of Slavic except for Slovene and Sorbian (Janda 1996: 175-8). The peripheral athematic verb class was limited to use with five lexical items at the dawn of the Slavic era, and today no Slavic language maintains it as a distinct verb class (Janda 1996: 9-11).

In relation to the Russian suffix shift, the Paradigm Structure Hypothesis can be tested by examining the distribution of *-a* vs. *-aj* suffixed forms across the paradigm. We expect the distribution to follow the independently established hierarchy. Thus the third singular form, which is most prototypical, will be most resistant to the change, retaining *-a* instead of shifting to *-aj*. The third plural form should be somewhat less resistant, followed by the first and second person forms that should be even less resistant to suffix shift. The imperative form should be relatively more receptive to the innovative *-aj* suffix, and the gerund and participle should show the greatest use of *-aj*. If this pattern is supported by a statistical analysis, the Paradigm Structure Hypothesis is confirmed and the null hypothesis can be rejected.

4.1 Testing the Paradigm Structure Hypothesis

An empirical study of corpus data was conducted in order to test the Paradigm Structure Hypothesis. Ultimately a logistic regression model was designed to handle the individual preferences for *-a* vs. *-aj* forms for each verb and its paradigm slots, as well as the factor of root-final consonant.¹¹ This model confirms the expected hierarchy, with one exception: the present active participle, which uses less *-aj* than expected. We argue below that this discrepancy is well-motivated on the grounds of formal similarities within the paradigm. On the whole, however, the statistical model confirms the Paradigm Structure Hypothesis.

¹⁰Of course it is possible for seemingly peripheral items to suddenly become very productive rather than being eliminated. For an in-depth study of several such cases, see Janda (1996), which shows that this kind of expansion requires special circumstances that support the interpretation of a marker as prototypical rather than peripheral in the given context.

¹¹The authors gratefully acknowledge the generous assistance of R. Harald Baayen in designing this model and guiding our interpretation of the results.

All sentences containing relevant forms of the thirty-seven verbs that are undergoing the Russian suffix shift were extracted from the RNC, yielding 11,460 verb forms. The distribution in terms of percentage of *-a* (as opposed to *-aj*) forms is presented in Figure 1.

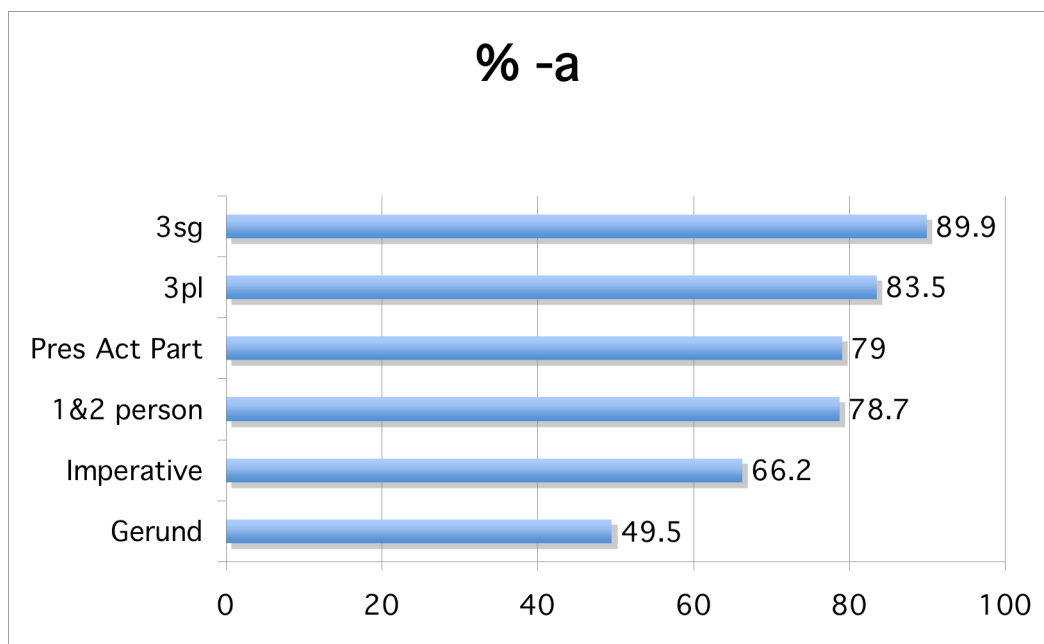


Figure 1: Distribution of *-a* suffix across paradigm forms (in percent)

Whereas a chi-square analysis of the distributional differences between the various paradigm forms suggests that these differences are significant,¹² chi-square is an unsatisfactory measure for a number of reasons. For one thing, chi-square requires that all observations be independent, but in this data some verbs had more “votes” to cast than others, since one verb, *ščepat* ‘chip’ contributed only two forms to the data, whereas most others had many more, with the maximum reached by *prjatat* ‘hide’, with 1343 forms. Since different verbs have different frequencies, if they also have different preferences for *-a* vs. *-aj*, a chi-square analysis would inflate the statistical significance. It is indeed the case that the various verbs show individual preferences, as visualized in Figure 2, where the vertical dimension in each verb’s graph represents preference for *-a* (toward the top) as opposed to *-aj* (toward the bottom).

¹²Chi-square values both for the entire distribution and pairwise between the parts of the paradigm (3sg vs. 3pl, 3pl vs. 1&2person, etc.) are all significant ($p < 0.001$) with the exception of 1&2person vs. present active participle.

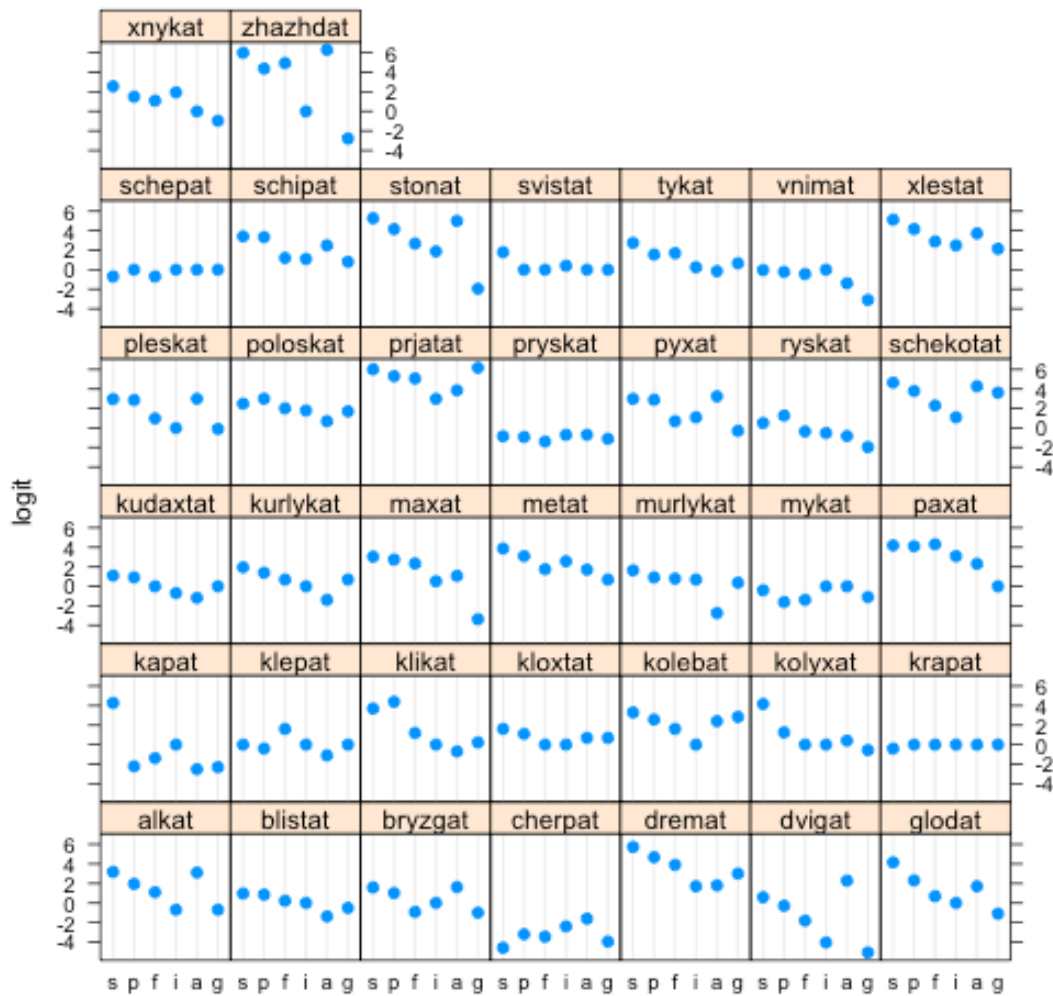


Figure 2: The log odds (of *-a* versus *-aj*) for each of the six paradigm slots ('s': third person singular, 'p': third person plural, 'f': first and second person, 'i': infinitive, 'a': active participle, 'g': gerund). Log odds were calculated after backing off from zero by adding 1 to all counts. A log odds greater than zero indicates a preference for *-a*, a log odds smaller than zero a preference for *-aj*.

Whereas *prjatat* 'hide' clearly prefers *-a*, other verbs, such as *čerpat* 'scoop', show the opposite preference. Furthermore, verbs also differ in terms of which paradigm forms are used most frequently. *Žaždat* 'thirst' and *maxat* 'wave' are of overall similar frequency (with 1255 total forms for the former and 1232 for the latter), but their distribution over the paradigm is quite different: *žaždat* 'thirst' provides 542 past active participles as opposed to only 49 for *maxat* 'wave', and while there are only 15 gerunds formed from *žaždat* 'thirst', the figure for *maxat* 'wave' is 237. In addition to these individual preferences, there is another confounding factor, namely preferences dependent upon the root-final consonant, which for these verbs can be a dental, velar, or labial. Figure 3 presents the differing probabilities of the *-a* vs. *-aj* suffix according to the place of articulation of the root-final consonant.

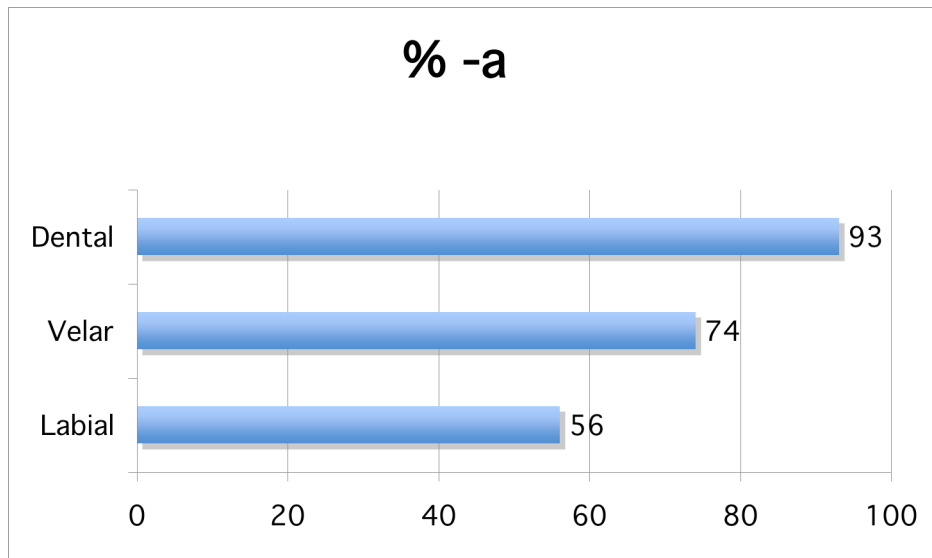


Figure 3: Distribution of -a suffix across root-final consonants (in percent)

A logistic regression model makes it possible to responsibly account for these factors and discover whether there are indeed differences in the use of *-a* vs. *-aj* across the paradigm forms. The mixed-effects model is designed to analyze the contributions of paradigm slot, individual verb's preferences, and preferences associated with place of articulation.¹³ Table 2 presents the coefficients resulting from this model.

	Estimate	Standard Error	z -value	p-value
a, dental (intercept)	3.738	0.915	4.085	<0.0001
f - a (contrast)	-0.075	0.483	-0.154	0.8774
g - a (contrast)	-2.591	0.707	-3.663	0.0002
i - a (contrast)	-0.988	0.693	-1.425	0.1542
p - a (contrast)	0.998	0.366	2.731	0.0063
s - a (contrast)	1.513	0.432	3.502	0.0005
labial - dental (contrast)	-3.382	1.164	-2.906	0.0037
velar - dental (contrast)	-2.562	0.967	-2.649	0.0081

Table 2: Coefficients of the mixed-effects model, with associated z- and p-values

The statistical software selects the active participle (coded “a”) and the dental place of articulation as its baseline (= “intercept”) and measures contrasts from that reference point.¹⁴ The p-values in the right-hand column indicate that, even when all other sources of variation are taken into account, most of these contrasts are still significant. The two exceptions are the contrast between the active participle and the 1&2 person and the contrast between the active participle and the imperative. Figure 4 gives a

¹³The code for this model in the R statistical software package is: `lmer(cbind(a, aj)~Paradigm + Place + (1+Paradigm|Verb), data=dat, family="binomial")`. For an in-depth discussion of the random effects structure of this mixed-effects model, and its role in accounting for the non-interdependence between the observations for a given verb across its paradigm, see Janda, Nessel & Baayen (forthcoming).

¹⁴The R package selects the level used as the intercept alphabetically according to the level names. For our data, this yields “a” (as opposed to “f”, “g”, “i”, “p” and “s”) and “dental” (as opposed to “labial” and “velar”) as the levels for the intercept.

graphical representation of the relationships among the paradigm slots and how the mixed-effects model has accounted for them.

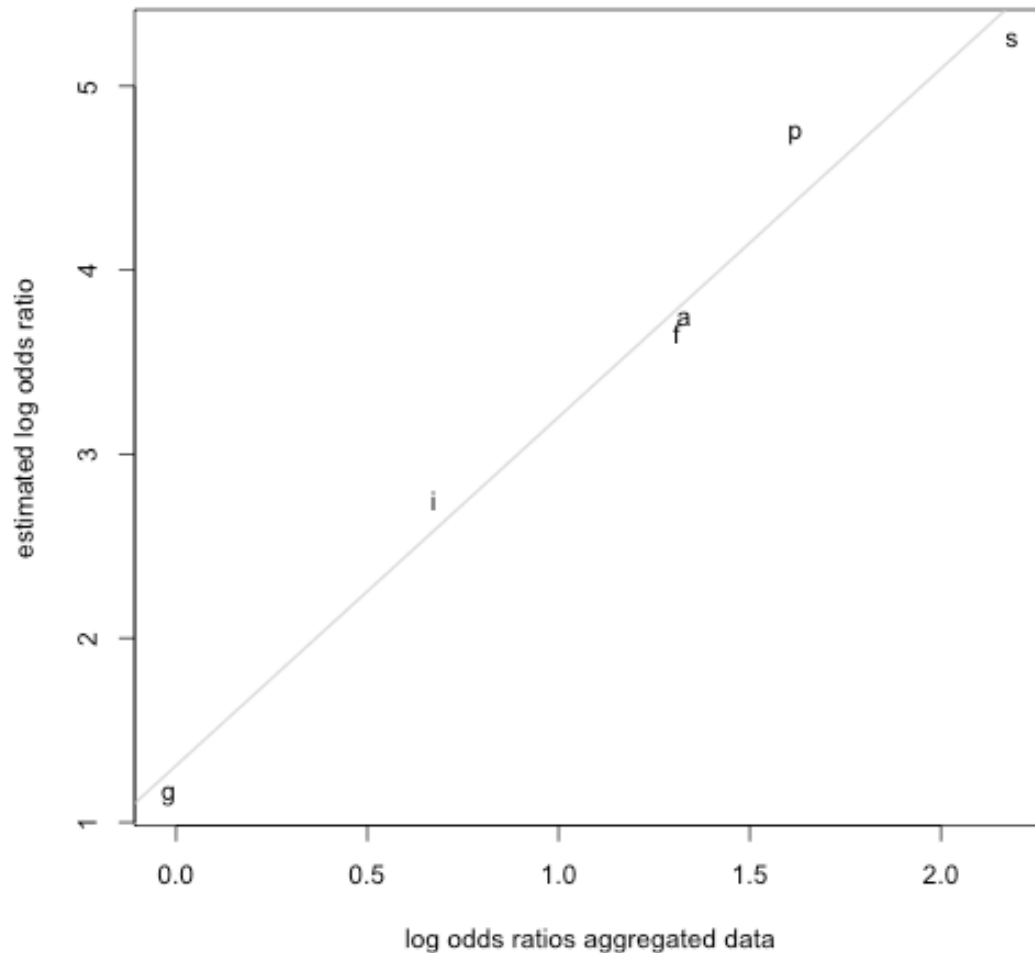


Figure 4: The log odds ratios for the data aggregated by paradigm slot compared to the corresponding log odds ratios as estimated by the mixed model ('s': third person singular, 'p': third person plural, 'f': first and second person, 'i': infinitive, 'a': active participle, 'g': gerund)

The log odds ratio measures the odds of the *-a* suffix vs. the *-aj* suffix, so a higher value indicates higher odds for *-a*, while a lower value indicates lower odds for *-aj*. The x-axis in Figure 4 represents the values that would be expected in a model that did not take all factors into account, and the y-axis represents the values of our mixed-effects model. We see that the two values are highly, but not perfectly correlated, since the values of the mixed-effects model include a correction introduced to account for the verb-specific and place of articulation-specific variation.

It is important to note that the separation between the paradigm slots is preserved in our model, and that, with one exception, this distribution follows the expected cline. Thus the third singular shows the strongest retention of the *-a* suffix, followed by the third plural, then the first and second person forms, and after those come the imperative and finally the gerund with the highest implementation of the *-aj*

suffix. The exception is the present active participle, which is nearly juxtaposed with the first and second persons on Figure 4.

The behavior of the present active participle is likely strongly influenced by formal factors, since this participle is a “parasitic formation” that is dependent upon the third person plural form.¹⁵ We can hypothesize that if two cells in a paradigm are formally closely related, they will display similar behavior with regard to the suffix shift. Table 3 illustrates the close formal relationship between the two forms.

	3pl ending:	Present Active Participle suffix:
1 st conjugation verbs	/ut/	/uʃʲ/
2 nd conjugation verbs	/at/	/aʃʲ/

Table 3: The “parasitic” relationship between the Present Active Participle suffix and the 3pl ending

For any given verb, the third person plural and present active participle form always include the same vowel, and furthermore, /t/ and /ʃʲ/ are associated by means of consonant alternations (cf. /otvratʲitʲ/ ~ /otvraʃʲu/ ‘repel [infinitive ~ first singular]’). It is possible to state a rule of referral (or metarule) according to which the participle is formed on the basis of the third person plural form by replacing the /t/ with its alternant /ʃʲ/. Since the present active participle is parasitic on the third person plural form, we would expect the present active participle to behave similarly to the third person plural. This expectation is borne out by the facts, since the suffix shift data shows that the participle ranks between the third person plural and the first and second persons.

The statistical analysis confirms the Paradigm Structure Hypothesis. Data on the Russian suffix shift indicate that the verbal paradigm is structured hierarchically and that diachronic change is implemented most at the periphery of the paradigm. The distributional facts are documented, but we must ask why we have this distribution. In section 3 we suggested primarily semantic motives (in terms of prototypicality) for the expected distribution. But the fact that we obtained the expected distribution does not mean that we have correctly identified its motivation. Before asserting that the semantics of verbal categories are the primary determining factor, we need to examine an alternative explanation, namely that this distribution might be attributable to frequency.

5. Does frequency account for this distribution?

The relationship between frequency and semantic markedness/prototypicality is controversial. Some researchers argue that high frequency is a symptom of unmarkedness or prototypicality (Andersen 1989: 28-30, Andrews 1990: 136-165, Comrie 1983: 85, and Maiden 1992: 287), whereas others ascribe a more explanatory role to frequency (Bybee 2001:129). In this section we compare the ranking of paradigm forms established on semantic grounds and confirmed by the distribution of the suffix shift with the ranking of forms by frequency. Whereas the frequency

¹⁵ For a thorough analysis of Romance verbs, where formal factors appear to influence diachronic change in the inflectional paradigm, see Maiden (1992 and 2005).

distribution largely parallels that of the suffix shift, frequency alone does not account for all of the data.

In discussing frequency effects in language change, Bybee (2008: 956-7) distinguishes between change due to automatization and change motivated by analogy (which is, according to Bybee, a result of imperfect learning). In the case of automatization, high token frequency promotes change since high frequency facilitates a high degree of automatization. Analogy, by contrast, shows the opposite effect, where high frequency elements tend to resist change because they support good mastery of a pattern that is thus resistant to change (cf. also Bybee 1985: 51 and Manczak 1980).

The Russian suffix shift is an example of analogy since the *-aj* suffix yields regularization and simplification of the inflectional paradigm (removing a consonant alternation and preserving the suffix in the present; replacing a non-productive pattern with a productive one). Thus we expect that the forms with the highest frequency should resist suffix shift, while the forms with the lowest frequency should embrace the innovation.

Table 4 compares the suffix shift hierarchy observed in the data and supported by semantic and formal considerations with the hierarchy that would be predicted on the basis of frequency alone based on the counts in our database.

Ranking according to semantic and formal considerations, confirmed by statistical model		Ranking according to frequency	
form	% of <i>-a</i> retained	form	frequency count
3sg	89.9%	3sg	4501
3pl	83.5%	Pres Act Participle	2105
Pres Act Participle	79.0%	3pl	1894
1&2 Person	78.7%	Gerund	1685
Imperative	66.2%	1&2 Person	964
Gerund	49.5%	Imperative	311

Table 4: Comparison of rankings according to semantics vs. frequency

Frequency correctly predicts the order of four of the forms, namely: 3sg > 3pl > 1&2 Person > Imperative. However, frequency does not account for the ranking of the gerund, which is quite frequent, but nevertheless by far the most innovative form. Frequency also gives an incorrect ranking for the present active participle, which is more than twice as frequent as the 1&2 person forms, but has almost the same rate of retention of the *-a* suffix. In section 4.1, we suggested that the ranking of the present active participle is due to its formal relationship with the 3pl. In a comparison of frequency and semantic factors, the participle should therefore arguably be set aside. The main difference between the factors we compare, then, is that semantic markedness and prototypicality yield better predictions for the gerund.¹⁶

¹⁶One could argue that the frequencies observed in our database are biased because they are based on a mainly written corpus, and that gerunds and participles are likely to be less frequent in spoken Russian. Though a corpus of spoken Russian is under development on the RNC site, it is far smaller than the written corpus, so it is not possible to make a meaningful comparison between spoken and written frequencies at this point.

A more serious argument against frequency as a decisive factor for suffix shift in Russian verbs pertains to the statistical analysis we have carried out. As explained in section 4.1, our statistical model supports the interpretation that paradigm slot is relevant for the distribution we observe even when frequency has been taken into consideration. This means that even if frequency may play a role in suffix shift, frequency alone is not a sufficient explanation for the data in this study. However, we acknowledge the need for further research in order to corroborate or disprove our results and thus shed light on the complex relationship between frequency and semantic markedness/prototypicality.

6. Conclusion

Based on previous research on paradigms and their structures, we propose that paradigms are a valid construct and that they have internal structure. Since the observed differences among paradigm forms involve asymmetric relationships based on markedness and prototypicality, we propose that the structure of the paradigm conforms to that of the radial category, with a central prototype related to more peripheral members. Given this structure and known markedness and prototypicality relationships among members of the verbal paradigm, it is possible to establish the following expected structure, with the more prototypical members toward the left:

3sg > 3pl > 1&2 > Imperative > Gerund/Participle.

The expected structure gives us a concrete opportunity to test the Paradigm Structure Hypothesis using data documenting the Russian suffix shift. Our prediction is that the most prototypical forms resist the language change, whereas the less prototypical forms implement it. A logistic regression model designed to account for the various sources of variation shows that paradigm slot is indeed a robust predictor of the implementation of the language change, and the overall order of the slots is confirmed. The one exception is the participle, which is less likely to participate in the language change than one would expect on the grounds of semantic factors such as markedness and prototypicality. The present active participle, however, is a “parasitic” form derived directly from the third person plural form, and it appears that this close formal relationship has motivated a reduced implementation of the language change, since the third person plural is more prototypical than the participle. We entertain the possibility that the frequency of the paradigm forms might be the motive for the distribution, however frequency leads to incorrect predictions for both the gerund and the participle, and paradigm slot is recognized as a statistically significant factor in our model even when frequency is taken into account.

Our empirical study supports the Paradigm Structure Hypothesis that paradigms are a valid concept, that they have structure, that their structure is motivated on semantic grounds, and that this structure comports with that of the radial category. Further studies of how on-going diachronic changes progress through inflectional paradigms are needed in order to corroborate this hypothesis and further explore the relationship between frequency and semantic factors in structuring paradigms.

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