Connectedness: Papers by and for Sarah VanWagenen
UCLA Working Papers in Linguistics 18: 48–58
Carson T. Schütze & Linnaea Stockall (eds.), 2014

Asymmetries in priming of verbal and nominal inflectional affixes in Russian*

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Introduction

Lexical priming has been used extensively to probe the nature of lexical representations in the speaker's mind. Priming effects have been found in a number of studies for roots, stems, and derivational morphemes (Marslen-Wilson et al. 1996, Feldman 2000, Rastle et al. 2000, Schluter 2013, and many others). On the other hand, priming of inflectional morphemes is underinvestigated, and the results of existing studies are mixed (see 1.2). Although the distinction between inflection and derivation is not categorical, inflectional morphemes typically express grammatical or syntactic information and in this respect have a very different semantic content compared to roots and derivational morphemes. This difference in meaning could potentially be correlated with different priming effects for inflectional vs. derivational morphemes.

In this paper, we report an experiment investigating inflectional priming in a richly inflectional language, Russian. We seek to establish whether nominal and verbal inflection produce priming effects comparable to those previously found for derivational morphemes. We find robust inflectional priming effects in verbal, but not nominal inflection. The implications of this finding and avenues for further work are discussed.

1 Background

1.1 Lexical priming and models of lexical access

In lexical priming experiments, participants see or hear a string of letters/sounds (the *prime*), followed by another string (the *target*). They are asked to identify the target as quickly and as accurately as possible either as a real word of their language or as a non-word, usually

*We are grateful to the UCLA Department of Linguistics for providing partial support for this project. We also thank Carson Schütze for guidance in experimental design and helpful comments, and Igor Yanovich and Olga Fedorova for their help with logistics in running our experiment at the Moscow State University. As usual, all shortcomings are our own.

by a button press, and their accuracy rate and reaction times (RT) are recorded. The key assumption is that lexical representations are accessed and activated when a receiver hears or sees a string of sounds or letters that correspond to that representation. Residual activation from accessing that lexical representation then leads to faster access on a subsequent exposure to the same representation. Consequently, repetition of the probe as a target is facilitatory, i.e., results in speeded reaction time to the target: *happy* primes *happy* (*happy* → *happy*). Form overlap (orthographic or phonological) between the prime and the target can also produce facilitation effects, but only when the prime is presented for a very short time. Otherwise, form overlap most often leads to slower responses presumably due to competition (Luce et al. 1990).

Interestingly, morphological derivatives of a stem also prime words consisting of just that stem: *happiness* → *happy* and vice versa *happy* → *happiness* (Marslen-Wilson et al. 1994). Further, derived words that share a derivational affix, but not a stem, also prime one another, e.g., *happiness* → *darkness*. This morphological priming obtains even in conditions in which the effects of semantics and of form do not (Bentin and Feldman 1990, Van Wagenen 2005, Duñabeitia et al. 2008, among others). This fact has been taken as support for morpheme-based models of processing (e.g., Taft and Forster (1975)). In such models, morphological parsing takes place first, and word representations are activated via separate morphemic representations. So, on this view morphological priming effects are due to activation of the *same* morphological representation at an early stage of processing. Additional support for early morphological decomposition comes from studies that show priming even for pseudo-morphemes (e.g., *corner* → *corn*), suggesting that the parser initially attempts to strip away any potential affixes and is meaning-blind (Rastle et al. 2004, McCormick et al. 2008).

An alternative model of lexical access is a "supra-lexical" model proposed by Giraudo and Grainger (2000; 2001). This model maintains that visual or auditory stimuli directly activate whole-word representations, before further morphological and semantic processing takes place. On this account, priming effects result from the morphological relations and the nature of semantic connectivity between words at the higher "supra-lexical" level which then leads to faster semantic processing and recognition. For other similar proposals see Butterworth (1983), Seidenberg and Gonnerman (2000). Most support for supra-lexical processing comes from the fact that priming effects are sensitive to the degree of semantic overlap, surface-frequency of the prime, neighborhood density, and other lexical (rather than morphological) factors (Giraudo and Grainger 2000, Voga and Giraudo 2009). To sum up, the exact mechanisms of lexical processing still remain controversial. We hope that additional evidence from inflectional morpheme priming will contribute to a more complete picture in this domain.

1.2 Previous studies of inflectional priming

A couple of morphological priming studies focus on morphology of Slavic languages. For example, Reid and Marslen-Wilson (2000) report a modest morphological priming effect (18ms) in a Polish cross-modal priming task for a group of four affixes, two of which lie somewhere in the middle on the inflection/derivation spectrum (the diminutive suffix and the aspectual prefix). The effect was significant when the data for all four suffixes was considered together as a group.

Smolìk (2010) reports two lexical priming experiments investigating the effects of stimulus-onset-asynchrony (SOA) on inflection priming in Czech verbs and nouns. His hypothesis was that in masked priming (with short SOA), identical and homophonous inflections should prime the target equally well, because, as mentioned in the previous section, at the early stage of lexical processing morphological decomposition is meaning-blind. On the other hand, with longer SOA, identical morphemes should exhibit greater priming than merely homophonous morphemes. This hypothesis was only partially (if at all) confirmed. For both SOAs in nouns, the baseline responses (with a prime XXXX) were significantly faster than responses in the identity condition — a result that goes against the typical findings. There was no significant difference between the baseline and the homophony conditions. In trials with verb targets, there were only two conditions: the identity and the homophony condition. With short SOA (masked priming) there was a marginally significant tendency for faster responses in the identity condition. This difference became significant with long SOA. This last result is consistent with the hypothesis, but it's not clear whether it was due to a priming effect for verbal inflection or to an inhibitory effect in the form-related homophony condition (or both).

Several studies focused on the morphological structure of Semitic languages, due to the unique opportunities it presents for decoupling the effects of segmental and morphological overlap. Boudelaa and Marslen-Wilson (2004) investigated Arabic verbal morphology using masked, cross-modal, and auditory-auditory priming. Arabic, like other semitic languages, has a "root and pattern" morphology, where words consist of the consonantal roots interleaved with vocalic melody following a particular pattern. Boudelaa and Marslen-Wilson were interested in investigating whether the word pattern corresponds to two distinct morphemes (as proposed by McCarthy (1981)): the abstract CV-skeleton and the vowel tier. For our purposes, the important point is that the CV-skeleton and the vowel melody typically encode grammatical, inflectional information. In a masked priming experiment Boudelaa and Marslen-Wilson found a significant effect of the word pattern (words sharing both skeletal and vocalic morphemes), and a more modest priming effect of the CV-skeleton, but no priming effect of the vocalic melody on its own. Very similar results were found in the cross-modal and auditory versions of the experiments. The fact that in all three experiments there was a priming effect of the CV-skeleton which involves no phonological overlap, but has a clear grammatical function (e.g., it encodes transitivity, reciprocity, morphological category) was taken as evidence for the skeleton as a separate cognitive unit. However, lack of priming for the vocalic melody which also encodes grammatical information (e.g., active/passive distinction) was surprising.

Priming effects of the "word pattern" (the skeleton and the vowel tier) have also been investigated in Hebrew (Frost et al. 1997, Deutsch et al. 1998). In these studies, the researchers found that while both verbs and nouns showed root-priming effects, only verbs showed word-pattern priming. The authors hypothesized that this asymmetry was due to the fact that the number of verbal patterns in Hebrew is very small compared to the number of nominal patterns (7 vs. more than 100), and the fact that the verbal patterns typically encode inflectional meanings and are productive, while many nominal patterns are derivational in nature and can be irregular. Based on their findings, the authors suggest that inflectional morphemes are more likely to be stored as separate lexical units due to their frequency and semantic transparency.

2 Experiment

This experiment used a visual immediate repetition priming paradigm in which the primes and targets were presented orthographically immediately following each other. Our hypothesis was that identical inflectional morphemes in the prime and the target would lead to faster RTs in the lexical decision task.

2.1 Stimuli

The stimuli consisted of 96 items, 48 of which were phonotactically plausible non-words (fillers). The other 48 were composed of 22 nouns, 22 verbs, 2 adjectives and 2 adverbs. Only the noun and verb data will be considered here. Each non-filler target was paired with three different primes forming three conditions, summarized in Table 1.

Table 1: Experimental conditions and examples for verbal and nominal inflection

Category	Condition	Prime	Target
noun	baseline	k sʲetatʃkʲ-e	na ʒivat-ax
		to net-Dat.sg.	on bellies-Loc.pl
	identity	f kulak-ax	na ʒivat-ax
		in fists-Loc.pl.	on bellies-Loc.pl
	form	fprasonkax	na ʒivat-ax
		half asleep (adv.)	on bellies-Loc.pl
verb	baseline	vʲɪza-tʲ	trʲəsʲ-ot
		knit-infin.	shake-3p.sg.pres
	identity	vʲɪrnʲ-ot	trʲəsʲ-ot
		return-3p.sg.pres.	shake-3p.sg.pres
	form	patːçot	trʲəsʲ-ot
		count (n).	shake-3p.sg.pres

Most of the nouns were preceded by a preposition for naturalness, since we previously found that speakers had a hard time parsing inflected nouns out of context. Additionally, the prepositions served to disambiguate case suffixes given that several nominal inflections in Russian are homophonous. The prepositions were always different between the target and the prime to rule out prepositional priming effects. Since presence of prepositions could have contributed to structural priming, prepositions were also included in the baseline condition in which the target was paired with a semantically, morphologically, and phonologically unrelated word of the same category. So, any prepositional effects should be subtracted out in the comparison between the baseline and the identity condition. In the form condition the target was paired with a word that orthographically and phonologically (but not morphologically) overlapped with the target suffix, and in the identity condition, the target was paired with a word that contained the same inflectional suffix. All primes were matched for the number of syllables (and roughly for the number of letters in their orthographic representation), as well as lemma- and surface frequency, and morphological family size. Inflectional suffixes used in this experiment are summarized in table 2. Almost all these suffixes are cumulative, expressing more than one grammatical function. The only exceptions are the three verbal past tense forms, which contain two suffixes, a tense marker and a gender/number marker, and verbal reflexive forms which contain an additional separate reflexive suffix. (Forms separated with a slash in the table are allomorphs.)

Table 2: Suffixes used in the stimuli

Nominal Inflections		Verbal Inflections	
-ax	Loc. pl.	-l-i	past – pl.
-om	Instr. sg. Class I	-l-a	past – fem. sg.
-oj	Instr. sg. Class II	-l-Ø	past – masc. sg.
-u	Dat. sg. Class I	-j	imperative
-i/-a	Nom. pl.	-t^j-s^ja	inf. – reflexive
-e	Loc. sg. Class II	-ti/t^j	inf.
-u	Acc. sg. Class II	-it/-ot	pres. 3p. sg.
-a	Gen. sg. Class I	-im/-om	pres. 1p. pl.
-i	Gen. sg. Class II/III	-ash/-osh	pres. 2p. sg.
-ami	Instr. pl.	-ote	pres. 2p. pl.
-ej/-ov	Gen. pl	-ut	pres. 3p. pl.

2.2 *Experimental Design*

We used a Latin-Squares counterbalanced design, to insure that the same targets appeared in each experimental condition and that a subject sees each target word only once. Subjects were randomly assigned to one of three groups, which differed based on what item was paired with what condition. This is summarized in table 3.

Table 3: Experimental Design

Group 1	Group 2	Group 3
items 1-16 form	items 1-16 identity	items 1-16 baseline
items 17-32 identity	items 17-32 baseline	items 17-32 form
items 33-48 baseline	items 33-48 form	items 33-48 identity

2.3 *Subjects and Procedure*

36 undergraduate students from the Moscow State University participated in the experiment. They were all monolingual native speakers of Russian between ages of 17 and 21. The experiment was implemented using the Psyscope experimental software (Cohen et al. 1993),

and carried out on a Macintosh laptop using an external button-box. Each trial consisted of the following sequence of events: a presentation of the star in the center of the screen for 250ms to focus attention, followed by the prime presented for 300ms, followed by the target presented for 350ms. Subjects were instructed to make a lexical decision on the target by pressing a "yes" (it's a word) or "no" (it's not a word) button. Participants were given 3000ms from the start of the target presentation to respond. A new trial began immediately after participants responded or after the time allotted had expired. There were 16 practice trials preceding experimental items, and the whole experiment lasted about 10 min. Reaction time (calculated from the onset of the prime presentation) and accuracy were recorded.

2.4 Analysis and results

Following the standard practice, incorrect responses (8% of our data) were discarded and the outliers were corrected to the minimum or the maximum allowed values defined as plus or minus 2.5 standard deviations from a subject's mean. A mixed effects regression model on the log-transformed RTs was carried out with subject and item as random effects, and prime type (baseline, identity, form) and category (verb, noun) as the fixed effects. The random effects of the items were very negligible showing that there were no significant differences between individual items. The subject effects were more prominent which is what we would expect given that some people always respond slower than others.

Table 4: Results of a mixed-effects regression model

Random effects:

Groups	Name	Variance	Std.Dev.
Item	(Intercept)	0.004429	0.066551
Subject	(Intercept)	0.047764	0.218549
Residual		0.040422	0.201053

Fixed effects

	Estimate (log-scale)	*p*	
(Intercept)	6.4289	0.0001	
Type:form	0.0166	0.3602	
Type:id	-0.0025	0.8886	
Cat:v	0.0265	0.3314	
Type:form-Cat:v	0.0097	0.7248	
Type:id-Cat:v	-0.0583	0.0278	*

The model shows that for nouns (the reference category) there was no effect of prime, however, for verbs there was a significant facilitatory effect of the prime in the identity condition (49ms) as compared to the baseline ($p = 0.028$). There were no significant effects of form as compared to the baseline for either nouns or verbs, although form-related primes elicited slower responses to the target which is consistent with previous findings of inhibitory effects in the form condition. Exploring these effects further, we performed 4 within-model contrast comparisons (using the *multicomp* package in R to correct for multiple comparisons). These comparisons show that for verbs both differences (baseline−id and form−id) are statistically significant ($p < 0.05$). That is, subjects responded faster to verb targets in the morphologically related condition compared to the baseline (difference = 49ms) as well as compared to the form-related condition (difference=59ms). On the other hand, neither of these differences was significant for nouns.

The boxplots in figure 1 summarize the distribution of RTs and mean values for each sub-condition (included in parentheses in the labels on the x-axis).

2.5 Discussion

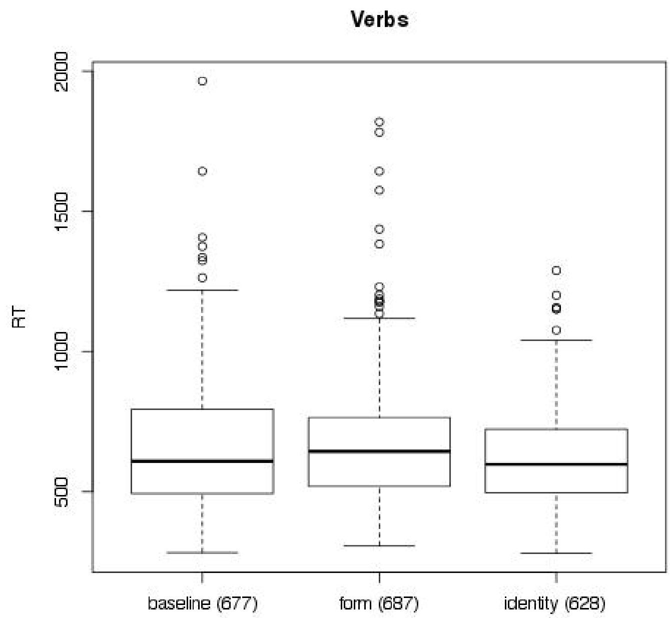
Overall, we found priming effects for verbal but not nominal inflectional morphemes. Priming in verbs was quite robust resulting in a relatively large decrease in latency, close to 50ms. These findings support our hypothesis that inflectional morphemes should produce similar, if not greater priming effects as derivational morphemes. However, our study also raises the question of why we did not find priming effects in nominal inflection: was this an artifact of our stimuli, or does it reflect a crucial difference between the lexical organization of verbal and nominal inflection in Russian? (Note that in the Czech study reviewed briefly in section 1.2, there were also asymmetries between verbs and nouns).

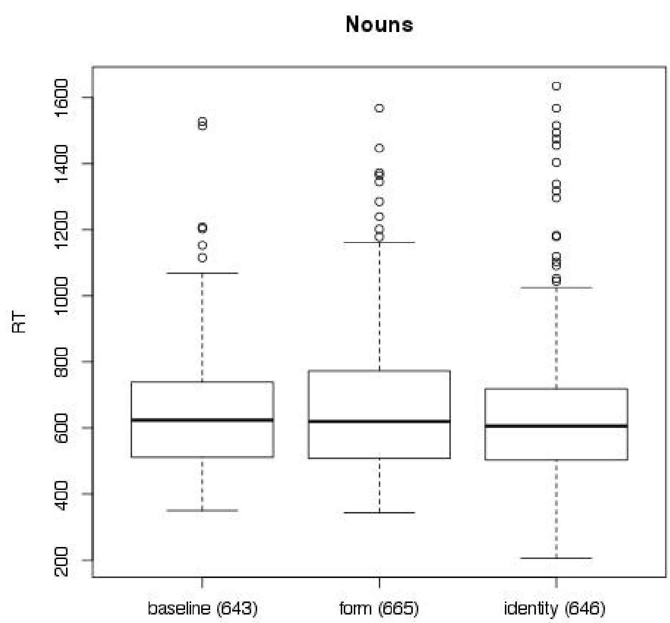
One possibility is that the lack of inflectional priming in nouns was due to the amount of polysemy and homophony present in the Russian nominal inflection (characteristic of Slavic more generally). Several studies by Bertram and colleagues on English, Dutch, and Finnish suggest that if a word contains a homophonous morpheme, it is stored or processed via the whole-word route (Bertram et al. 2000a;b). More specifically, these studies show that manipulations to the base frequencies of wordforms containing homophonous morphemes do not have an effect on the response latencies in a lexical decision experiment in contrast to manipulations of surface frequencies. On the other hand, response latencies to words that do not contain homophonous morphemes are affected by their base frequencies. On a morpheme-based view of lexical organization, we would not expect morphological priming to obtain for words that were stored as a whole (or always accessed through a whole-word route). The majority of nominal inflectional suffixes in Russian are homophonous. For example, in our stimuli 8 out of 13 nominal suffixes are homophonous with some other morpheme (usually another case-marker), while only 2 verbal suffixes are homophonous.

In addition, polysemy presents another possible problem. The use of different prepositions in the prime and the target in the identity condition could have triggered different "senses" of the same case morpheme. To the extent that the degree of semantic overlap has been shown to matter in priming effects, if two senses are not as closely related to each other, it is possible that they would not prime each other as strongly. Additionally, there might also be inhibitory effects due to activation of multiple senses (some support for inhibitory effects in processing of polysemy comes from Pylkkänen et al. (2006)). As an example of the kind of polysemy prevalent in the nominal inflection, consider a wide array of contexts in which a genitive can be used: it appears as a partitive (*kusok saxar-a* "piece of sugar"), in possessive constructions (*shapka muzh-a* "hat of (the) husband"), marking location (*okolo muzej-a* "near the museum"), or in genitive of negation constructions (*net saxar-a* "there's no sugar"). In contrast, verbal inflections (in particular, person-number agreement morphology) are not subject to multiple interpretations.

Finally, any morphological priming effects in nouns could have been "swamped" by the

Figure 1: The distribution of RT values in nouns and verbs





structural priming effects of the PREP+NOUN construction. However, no prepositions were used in the form-related controls, so we would at least expect to find a difference between the form and identity conditions in nouns which we do not. We conclude that more experimental data is needed to control for the possible confounds in nominal inflection discussed here. The question of whether nominal and verbal inflections are represented differently in the Russian speaker's mental lexicon remains an open one.

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