

# The inflected noun system in Serbo-Croatian: Lexical representation of morphological structure

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Repetition priming is examined for alternating and nonalternating morphologically related inflected nouns. In Experiments 1 and 2, latencies to targets in nominative and dative/locative cases, respectively, were invariant over case of prime. In Experiment 3, latencies to nominative-case nouns were the same whether the nouns were primed by forms in which the spelling and pronunciation of the common stem were shared (*nonalternating*) or not (*alternating*) with the nominative form. Results are interpreted as reflecting lexical organization among the members of a noun system. In Experiments 1 and 2, the pattern of latencies to primes suggests a satellite organization in which nominative forms are more strongly linked to oblique forms than oblique forms are to each other. In Experiment 3, atypical cases of alternating forms showed a different pattern of prime latencies, suggesting that the organization within a noun system may differ for alternating and nonalternating forms.

In these studies, we examined the role of morphology in the reading lexicon of speakers of Serbo-Croatian, the dominant language of Yugoslavia. The morphology of Serbo-Croatian is particularly interesting to study because it is substantially richer than that of English. Generally, in Serbo-Croatian, inflectional affixes are appended to nouns and adjectives, with the particular termination varying according to case, gender, and number. Analogously, for verbs, inflectional suffixes and sometimes infixes may vary with tense, aspect, person, number, and sometimes gender of the subject. The formation of diminutives, agentives, and other derivations—which are characteristic of Slavic languages—is similarly complex. Consequently, each Serbo-Croatian base word has many variants, yielding extensive families of morphologically related words.

In the present series of experiments, we explored in particular how the singular-case inflected forms of a word are related in the internal lexicon of adult readers who

are native speakers of Serbo-Croatian. The experiments represent an extension of earlier work by Lukatela and his colleagues (Lukatela, Gligorijević, A. Kostić, & Turvey, 1980; Lukatela et al., 1978), who investigated how individual inflected forms are recognized.

There are seven cases of inflected noun forms in Serbo-Croatian, which differ in their frequency of occurrence in printed text (Dj. Kostić, 1965). When singular inflected cases were presented in a lexical decision task, decision times for the nominative singular form of a noun were shorter than decision times for the same noun in (1) dative/locative and instrumental singular cases (Lukatela et al., 1978) and (2) genitive and instrumental cases (Lukatela et al., 1980). The decision times for all non-nominative (viz., oblique) forms were equivalent. Lukatela and his colleagues (Lukatela et al., 1980; Lukatela et al., 1978) proposed that in the lexicon, the singular cases of a noun make up a satellite-like system in which the nominative singular of the noun or base form has a special status in that it provides a nucleus around which the oblique cases cluster in a uniform fashion. This organization applies for inflected forms of both familiar and less familiar base words. That is, frequency of the nominative base word, but not frequency of inflectional case, governs reaction time.

The satellite-entries model reflects a position on a debated issue in the literature on how morphological structure may influence word recognition (see Caramazza, Miceli, Silveri, & Laudanna, 1985). In that literature, the lexical entries are considered to consist of stem mor-

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Table 1  
Examples of Regular Masculine and Feminine Singular  
Inflected Nouns and Their Frequencies

Case	Masculine	Freq.	Feminine	Freq.
Nominative	DINAR	13	RUPA	9
Genitive	DINARA	9	RUPE	8
Dative	DINARU	1	RUPI	<1
Accusative	DINAR	6	RUPU	6
Instrumental	DINAROM	2	RUPOM	2
Locative	DINARU	4	RUPI	2
Vocative	DINARE	<1	RUPO	<1

sonant with consonant) in other real words with the same orthographic structure as the real words in the experiment. All materials were printed in roman characters.

Each word appeared in three different singular cases: nominative, dative/locative, and instrumental. Each pseudoword also appeared with affixes for masculine or feminine words in the same inflectional cases. Words were chosen so that inflectional suffixation did not alter the spelling of the base form. Examples of regular masculine and feminine words in their seven inflected-case forms appear in Table 1.

**Procedure.** Subjects individually performed a lexical decision task: As each letter string appeared, the subject hit a telegraph key with both hands to indicate whether or not the string was a word. He/she hit the farther key (with index fingers) to signal "yes" and the closer key (with thumbs) to signal "no." All letter strings were typed in roman script, photographed, and mounted as slides. Stimuli were projected from a carousel projector that was equipped with a modified camera lens as a shutter and were displayed on a screen until after the subject responded (approximately 750 msec). The subject viewed the screen from a distance of 1 m, and letter strings subtended a visual angle between 2.6° and 3.9°. A dark field immediately preceded and followed each display. The interval between experimental trials was controlled by the experimenter and lasted about 2,000 msec. Reaction times were measured from the onset of the stimulus display.

**Design.** Three test orders were created. Each one included three priming conditions distinguished by the inflectional case of the prime, that is, nominative singular, dative/locative singular, or instrumental singular. (Case of prime was indicated as N1, D1, or I1, respectively.) All targets were in the nominative case. Half were masculine gender and half were feminine. (The conditions of nominative targets preceded by nominative, dative/locative, and instrumental singular primes were indicated as NN, DN, and IN, respectively.) Words appeared in the same serial position across all test orders, although the inflectional form of the prime varied. For example, the word RUPA (meaning *hole*) was presented in its nominative form as the target in the same serial position in all three test orders, but it was preceded in the same position by either RUPA, RUPI, or RUPOM as a prime.

Each subject viewed one test order. Therefore, subjects saw each morpheme twice, once in a prime and once in a target. The average lag between the presentation of the prime and the target was 10 items, and lags ranged from 7 to 13. Filler items were introduced to maintain appropriate lags, and a practice list of 10 items preceded the test list.

To summarize the experimental design, across test orders each target word in nominative case was preceded by its prime in nominative, dative/locative, and instrumental form. Within each order, a base morpheme occurred once in a target and once in a prime, and case of prime varied with item. Stated alternatively, all subjects viewed the three cases of prime on different target items, and, across test orders, each word was preceded by each case of prime.

## Results

Errors and extreme reaction times (greater than 1,200 msec or less than 350 msec) were excluded from all analyses. This procedure eliminated fewer than 4% of all responses. In addition, when a subject responded incorrectly to one member of a prime-target pair, both responses were excluded from subsequent analyses. The error-pairing procedure eliminated an additional 3% of all responses.

Mean reaction times for correct responses to nominative forms (Conditions N1, NN, DN, and IN) of masculine and feminine words were calculated and subjected to analyses of variance. Each comparison included an analysis for subjects, averaging over items ( $F_1$ ), and for items, averaging over subjects ( $F_2$ ). Means for Experiment 1 are summarized in Table 2.

For words, the effect of condition (N1, NN, DN, IN) was significant [ $F_1(3,114) = 26.53$ ,  $MSe = 1,759$ ,  $p < .001$ ;  $F_2(3,66) = 11.41$ ,  $MSe = 1,244$ ,  $p < .001$ ]. The effect of gender was not significant, although the interaction of condition  $\times$  gender approached significance in the subjects analysis but not in the items analysis [ $F_1(3,144) = 2.38$ ,  $MSe = 1,651$ ,  $p < .07$ ;  $F_2(3,66) = .26$ ,  $MSe = 1,058$ ,  $p < .85$ ]. A second analysis that included only nominative targets (NN, DN, IN) revealed no significant differences among targets as a function of case of prime and no interaction involving gender. Therefore, the significant effect of condition in the earlier analyses is due to the difference between the N1 condition on the one hand and the three target conditions on the other; thus priming was full.

For pseudowords, neither the effect of condition nor that of gender was significant, although their interaction was significant only by a subjects analysis [ $F_1(3,114) = 3.98$ ,  $MSe = 2,032$ ,  $p < .01$ ;  $F_2(3,66) = 1.33$ ,  $MSe = 1,864$ ,  $p < .27$ ]. Inspection of pseudoword means indicates that familiarity with pseudoword targets slowed rejection latencies in the case of pseudo masculine noun forms and speeded rejection latencies in the case

Table 2  
Mean Reaction Times (in Milliseconds) to Nominative Targets  
(NN, DN, IN) and Their Respective Nominative-, Dative/Locative-,  
and Instrumental-Case (N1, D1, I1) Primes in Experiment 1

	Masculine		Feminine		Combined	
	Prime	Target	Prime	Target	Prime	Target
Words						
N1	600	NN 533	N1 576	NN 536	N1 588	NN 534
D1	665	DN 539	D1 672	DN 544	D1 668	DN 541
I1	680	IN 543	I1 661	IN 548	I1 670	IN 545
Pseudowords						
N1	682	NN 704	N1 729	NN 671	N1 705	NN 687
D1	723	DN 695	D1 721	DN 683	D1 722	DN 688
I1	768	IN 700	I1 773	IN 708	I1 770	IN 703

Note—NN, DN, and IN represent nominative targets preceded by nominative, dative/locative, and instrumental singular primes, respectively.

of pseudo feminine noun forms. Because the effect of condition on pseudowords was not significant, no analysis combining words and pseudowords is included.

An analysis of variance on mean reaction times for correct responses to word primes (Conditions N1, D1, I1) revealed a significant effect of case [ $F_1(2,76) = 40.22$ ,  $MSe = 4,269$ ,  $p < .001$ ;  $F_2(2,44) = 25.95$ ,  $MSe = 2,036$ ,  $p < .001$ ]. There was no effect of gender and, importantly for the satellite interpretation, no interaction of case  $\times$  gender [ $F_1(2,76) = 1.89$ ,  $MSe = 2,750$ ,  $p < .16$ ;  $F_2(2,44) = .78$ ,  $MSe = 2,036$ ,  $p < .47$ ]. Inspection of word means shows that for both masculine and feminine words, the nominative case was recognized faster than the oblique cases and recognition of oblique cases did not differ significantly.

An analogous analysis on pseudoword primes showed a significant effect of case [ $F_1(2,76) = 20.76$ ,  $MSe = 4,300$ ,  $p < .001$ ;  $F_2(2,44) = 3.92$ ,  $MSe = 7,006$ ,  $p < .03$ ] and an interaction of case  $\times$  gender that was significant by the subjects analysis only [ $F_1(2,76) = 4.90$ ,  $MSe = 2,800$ ,  $p < .01$ ;  $F_2(2,44) = .60$ ,  $MSe = 7,006$ ,  $p < .56$ ]. The pattern of pseudoword means revealed longer rejection latencies for instrumental forms than for nominative forms. For pseudo feminine noun forms, dative/locative latencies were similar to nominative latencies. For pseudo masculine noun forms, however, dative/locative latencies were intermediate between nominative and instrumental latencies and significantly different from each. All contrasts were significant at  $p < .01$ .

No analyses were performed on the error data, because some subjects made no errors and all subjects were very accurate. Out of 8 possible errors per condition, the mean number of errors in Conditions N1, D1, and I1 for words and pseudowords, respectively, were .47, .49, and .18 and .62, .69, and .64. The mean number of errors on targets in each condition (NN, DN, IN), computed independently of the error-pairing procedure, was less than .20 for both words and pseudowords.

Finally, mean reaction times for each prime word in its nominative (N1), dative/locative (D1), and instrumental (I1) forms were computed, and inflected forms of each word were correlated. To the extent that the various members of a noun system share a lexical entry or are equivalent on factors that contribute to reaction time in a lexical decision task (Balota & Chumbley, 1984), correlations between latencies for any pair of inflected forms will be significant and all pair-wise correlations will be equal. The correlations of nominative with dative (N1 and D1), nominative with instrumental (N1 and I1), and dative with instrumental (D1 and I1) were  $r = .57$ ,  $r = .49$ , and  $r = .67$ , respectively. (For correlations based on 24 items, where  $df = 22$ , values of  $r$  greater than  $|.40|$  are significant at the .05 level.) Analogous correlations computed on latencies to pseudonominatives, pseudodatives, and pseudoinstrumentals did not approach significance.

## Discussion

Significant priming of nominative targets occurred when real words were presented for lexical decision in a repetition priming procedure.

The effect was obtained with both identity primes (NN) and inflected relatives (i.e., morphological primes: DN and IN). The means of the three target conditions did not differ significantly, and their numerical values differed overall only by 10 msec. This outcome (viz., statistically full priming with small numerical differences between means) replicated results reported previously with English materials (Fowler et al., 1985). One account provided by Fowler et al. is that the small numerical differences in priming may reflect an episodic component that augments the lexical effects of repetition priming by selectively inflating the identity prime condition. However, as argued elsewhere, this effect cannot be visual in nature (Feldman, 1984; Feldman & Moskovljević, in press) because the magnitude of facilitation is as large when prime and target are printed in different alphabets as when they are printed in the same alphabet. Evidently, in the present experiment, presentation of related inflected-case forms of a word facilitated the subsequent lexical decision about that word in nominative case, and both identical and morphological forms primed fully. This outcome can be explained in terms of a full spreading of activation among individual inflected forms of a noun system (i.e., satellite entries) and its nominative nucleus.

The suggestion of an interaction of condition  $\times$  gender for words indicated that the magnitude of the facilitation due to repetition was larger for masculine nouns than for feminine nouns. However, inspection of means revealed that the effect was carried by a difference between masculine and feminine nominative primes (N1) rather than by targets (NN, DN, IN), and the outcome of an analysis restricted to target latencies supported this interpretation. In summary, decision latencies to masculine and feminine target words were equally fast when an identical or morphologically related prime preceded it.

Among pseudowords, evidence of a condition  $\times$  gender interaction made the absence of any overall facilitation with repetition equivocal. Inspection of means suggested that decisions about masculine-gender targets were slowed by a previous presentation of the identical prime, whereas decisions about feminine-gender targets were facilitated. (Collapsing over gender, therefore, gave no evidence of facilitation with repetition.) This effect is curious, because neither gender nor the interaction of condition  $\times$  gender was significant for real word targets, and because the only difference between masculine and feminine nominative-case pseudowords was the addition of an A suffix on feminine forms. In all other respects, the assignment of gender and, consequently, inflectional affixes to the two groups of pseudowords was essentially arbitrary. At this point, we can suggest no explanation as to why repetition sometimes facilitated and sometimes impeded decision latencies for pseudowords.

The primary outcome of Experiment 1, based on the pattern of facilitation using the repetition priming procedure, was that both nominative- and oblique-case forms can prime a nominative target. Both identity primes and morphologically related primes exhibited statistically full

priming with nominative targets. Following Stanners et al. (1979) and Fowler et al. (1985), we interpret repetition priming as an index of the interrelation among forms of a noun in the internal lexicon. By this convention, all oblique-case forms were tightly linked to their nominative nucleus. The facilitation evidenced in the repetition priming procedure with inflected nouns of Serbo-Croatian can be conceptualized to mean that once a satellite entry is accessed, the nominative nucleus of the noun system is also activated.

The latency data for word primes provided a replication of previous results on inflected forms in Serbo-Croatian (Lukatela et al., 1980; Lukatela et al., 1978). Nominatives were recognized faster than other cases, and recognition of the oblique cases did not differ significantly. This outcome suggested that nominative forms are most accessible in the internal lexicon. Importantly, there was no interaction with gender. Masculine and feminine words displayed the same pattern of latencies among inflected forms, despite differences in the complexity of deriving inflected forms from a nominative form. Equally strong correlations between mean latencies of two oblique cases of a word (D1 and I1) or of a nominative and one oblique case (N1 and D1, or N1 and I1) support this interpretation.

In conclusion, the outcome of the present experiment buttresses the interpretation of Lukatela et al. (1980) in that it provided no evidence that the morphological relatedness among inflected forms of a noun was represented in the lexicon by a shared base morpheme and a set of transformations whose complexity governs recognition latency. It appears that masculine nouns, for which the nominative singular and base morpheme are isomorphic, and feminine nouns, for which the nominative singular includes an A affixed to a base morpheme, are represented lexically in the same manner.

In the pseudoword prime data, decision latencies varied with number of letters. For pseudo feminine items, nominative and dative/locative forms had the same number of letters, and they resulted in similar reaction times. Both differed from instrumental forms, which were one letter longer. For pseudo masculine items, by contrast, nominative forms, which had the fewest letters, were recognized significantly faster than dative/locatives, which were one letter longer than nominatives. Reaction times to both of these were faster than those to instrumentals, which were two letters longer than nominatives. In lexical decision, length effects for orthographically regular but meaningless letter strings have been reported previously in English and in other languages (e.g., Feldman & Turvey, 1983; Hudson & Bergman, 1985).

As reviewed above, the satellite-entries account posits a separate and complete entry for each affixed word and grants a special status to the nominative case. Because nominative-case forms served as targets in Experiment 1, the outcome of the experiment (i.e., full priming with nominative targets) is inconclusive with respect to lexical organization within the noun system. The present out-

come may reflect the alleged privileged position of the nominative case in the satellite configuration. Alternatively, the same result could also arise if the nominative singular case of a noun did not possess a special status within the noun system (i.e., if the principle of organization were uniform among all inflected forms). According to the homogeneous interpretation, however, the same pattern of full priming effects would emerge with any oblique-case target. In Experiment 2, we continued to explore the characteristics of the noun system. We used the pattern of facilitation in repetition priming to look for inhomogeneities in organization among entries. As in Experiment 1, it was our intention to ascertain how the principle of morphological relatedness operates within the noun system, specifically whether, as predicted by the satellite-entries account, there exist some inflected-case forms that retain a privileged status when the oblique form of a noun must be activated.

## EXPERIMENT 2

In Experiment 2, we asked whether primes that are morphologically related to their targets facilitate recognition of oblique-case targets as effectively as they facilitate recognition of nominative-case targets. Priming of dative/locative-case targets by nominative, dative/locative, and instrumental cases was examined. As in Experiment 1, an identity prime condition served as the criterion for determining full repetition priming. If inflected forms are defined relative only to the nominative singular, as posited in the satellite-entries account, then the instrumental singular case of a noun may facilitate lexical decision on the dative/locative singular case of a noun less than would the dative/locative case itself. That is, the priming of dative/locative target by instrumental-case forms may be partial. Alternatively, if the organization among cases of a noun is homogeneous, then priming for oblique targets would be comparable to priming with nominative targets.

### Method

**Subjects.** Thirty-nine first-year students from the Department of Psychology at the University of Belgrade participated in Experiment 2. None had participated in Experiment 1. All were native speakers of Serbo-Croatian, had normal or corrected-to-normal vision, and never had participated previously in a psycholinguistic experiment.

**Stimulus materials.** The same words and pseudowords presented in Experiment 1 were used in Experiment 2. Moreover, the original order of presentation was preserved with one exception. In the test list for Experiment 2, the dative/locative form, rather than the nominative form, appeared as the target. In Experiment 2, as in Experiment 1, all letter strings were printed in roman characters.

**Procedure.** The procedure in Experiment 2 was identical to that of the previous experiment.

### Results

Errors and extreme response times were eliminated from the present analyses, according to the same criteria used in Experiment 1. Fewer than 4% of all responses

were eliminated according to these criteria. An additional 2% of all responses were eliminated by the error-pairing procedure. Table 3 summarizes the mean recognition times for dative/locative target words and pseudowords in Experiment 2.

Analyses of variance, with condition (D1, ND, DD, ID) and gender as independent variables, were performed using subjects and items as random variables. As in Experiment 1, the effect of condition was significant for real words [ $F_1(3,114) = 59.48$ ,  $MSe = 2,158$ ,  $p < .001$ ;  $F_2(3,66) = 27.54$ ,  $MSe = 1,435$ ,  $p < .001$ ]. The effect of gender and the interaction of condition  $\times$  gender were significant in the subjects analysis [ $F_1(1,38) = 6.27$ ,  $MSe = 1,728$ ,  $p < .02$ ;  $F_2(1,22) = .93$ ,  $MSe = 3,589$ ,  $p < .35$ ] but not in the items analysis [ $F_1(3,114) = 2.98$ ,  $MSe = 1,913$ ,  $p < .04$ ;  $F_2(3,66) = 1.20$ ,  $MSe = 1,435$ ,  $p < .32$ ].

A subsequent set of analyses, including only dative/locative-target latencies (conditions ND, DD, ID), revealed a significant effect of prime condition [ $F_1(2,76) = 4.02$ ,  $MSe = 2,028$ ,  $p < .02$ ;  $F_2(2,44) = 3.17$ ,  $MSe = 790$ ,  $p < .05$ ] such that identity primes were more effective than instrumental primes. There was also a significant effect of gender by the subjects analysis [ $F_1(1,38) = 20.77$ ,  $MSe = 1,125$ ,  $p < .001$ ] but not by the items analysis [ $F_2(1,22) = 3.07$ ,  $MSe = 2,340$ ,  $p < .09$ ]. The interaction of condition  $\times$  gender was not significant.

An analogous analysis of pseudoword latencies showed a significant effect of prime condition [ $F_1(3,114) = 6.77$ ,  $MSe = 2,582$ ,  $p < .001$ ;  $F_2(3,66) = 2.75$ ,  $MSe = 1,952$ ,  $p < .05$ ]; however, no effect of gender and no interaction of condition  $\times$  gender were found. A subsequent analysis of pseudoword targets indicated a significant effect of condition such that instrumental-case primes facilitated less than did dative/locative- or nominative-case primes [ $F_1(2,76) = 3.37$ ,  $MSe = 2,848$ ,  $p < .04$ ]. This effect was not significant in the stimulus analysis, however [ $F_2(2,44) = 2.06$ ,  $MSe = 1,430$ ,  $p < .14$ ]. When word and pseudoword latencies (D1,

ND, DD, ID) were entered into one analysis, the interaction of condition  $\times$  lexicality was significant [ $F_1(3,114) = 15.72$ ,  $MSe = 1,938$ ,  $p < .001$ ;  $F_2(3,132) = 4.81$ ,  $MSe = 1,950$ ,  $p < .003$ ]. Words were facilitated more by repetition than were pseudowords.

An analysis of word primes revealed a significant effect of case [ $F_1(2,76) = 27.49$ ,  $MSe = 2,762$ ,  $p < .09$ ;  $F_2(2,44) = 22.14$ ,  $MSe = 1,055$ ,  $p < .001$ ]. Neither the effect of gender nor the interaction of case  $\times$  gender approached significance. An analogous analysis of pseudoword prime latencies revealed a significant effect of case [ $F_1(2,76) = 19.32$ ,  $MSe = 2,826$ ,  $p < .001$ ;  $F_2(2,44) = 7.02$ ,  $MSe = 2,393$ ,  $p < .002$ ] and a significant effect of gender [ $F_1(1,38) = 9.18$ ,  $MSe = 1,913$ ,  $p < .01$ ;  $F_2(1,22) = .75$ ,  $MSe = 7,156$ ,  $p < .40$ ]. The interaction of case  $\times$  gender was significant by the subjects analysis only [ $F_1(2,76) = 3.68$ ,  $MSe = 3,046$ ,  $p < .03$ ;  $F_2(2,44) = 1.44$ ,  $MSe = 2,393$ ,  $p < .25$ ].

No analysis could be performed on the error data. Out of 8 possible errors per condition, the mean number of errors on Conditions N1, D1, and I1 for words and pseudowords, respectively, were .27, .29, and .42 and .34, .24, and .51. The mean number of errors on targets in each condition (ND, DD, ID) computed independently of the error pairing procedure was less than .30 for both words and pseudowords.

Finally, mean recognition latencies for prime words in their nominative, dative/locative, and instrumental forms were computed and correlated for each word pair. For nominative with dative (N1, D1), nominative with instrumental (N1, I1), and dative with instrumental (D1, I1), the correlations were  $r = .69$ ,  $r = .66$ , and  $r = .71$ , respectively. These correlations, with  $df = 22$ , are all significant at the  $p < .05$  level. No pseudoword correlations were significant.

## Discussion

Overall, decision latencies were prolonged in the second experiment relative to those in the first. In light of the claim by Forster and Davis (1984) that magnitude of facilitation varies with word frequency (and hence reaction time) in unmasked presentations, no comparisons across experiments are offered. Inspection of decision latencies for word and pseudoword primes revealed a deviation from the characteristic satellite entries outcome. For words, dative/locative-case primes were responded to faster than were instrumental-case primes. Moreover, for pseudowords of both genders, responses to dative/locative- and nominative-case primes were nearly equivalent. It appears that the preponderance of dative/locative-case target words and pseudowords may have facilitated all dative/locative forms. This finding does not invalidate the analysis of repetition priming, however, because all comparisons are on dative/locative-case targets.

The strategy for interpreting repetition priming effects adopted in the present study has been to compare identity prime and morpheme prime conditions and to define full

Table 3  
Mean Reaction Times (in Milliseconds) to Dative/Locative Targets (ND, DD, ID) and Their Nominative-, Dative/Locative-, and Instrumental-Case Primes (N1, D1, I1) in Experiment 2

Masculine		Feminine		Combined							
Prime	Target	Prime	Target	Prime	Target						
Words											
N1	614	ND	576	N1	593	ND	551	N1	603	ND	563
D1	636	DD	563	D1	649	DD	542	D1	642	DD	552
I1	675	ID	580	I1	655	ID	566	I1	665	ID	573
Pseudowords											
N1	712	ND	691	N1	715	ND	686	N1	714	ND	688
D1	722	DD	688	D1	710	DD	679	D1	716	DD	684
I1	782	ID	710	I1	739	ID	699	I1	761	ID	705

Note—ND, DD, and ID represent dative/locative targets preceded by nominative, dative/locative, and instrumental singular primes, respectively.

facilitation as effects that are not different from the identity prime condition. Consistent with Experiment 1, Experiment 2 showed that lexical decision to nouns in the dative/locative case was facilitated by prior presentation of a morphologically related form. In contrast to Experiment 1, Experiment 2 showed that the instrumental singular primes produced only partial facilitation of dative/locative targets. Assuming that degree of facilitation indexes closeness of relation or extent of activation spread among morphological relatives, it appears that connections within a noun system are not uniform. In Experiment 2, oblique cases were primed more fully by themselves than by other oblique cases. This effect was demonstrated both for masculine nouns whose base morpheme and nominative were fully repeated in all oblique forms and for feminine nouns whose nominative was not completely reiterated in any oblique form. Evidently, the lexical organization for a system of inflected nouns includes connections that vary in strength. Moreover, appreciation of morphological relatedness does not depend on a full overlap of the letters that constitute the nominative-case form.

A comparison of the pattern of full and partial priming effects in Experiments 1 and 2 revealed some asymmetries in organization for inflected forms that argue against a homogeneous organization of morphological relatives. By the satellite-entries alternative, however, asymmetries are easily accommodated because the nominative form functions as the nucleus of an inflected-noun system. Specifically, the relationship between nominative and oblique cases was as strong as the relationship between oblique and nominative cases in that neither was significantly different from the identity prime condition. Because facilitation with instrumental primes was significantly different from that with identity primes, the relationship between two different oblique cases appears to be relatively attenuated. If inflected cases of a noun formed a homogeneous structure—either as fully represented but independent lexical entries or as entries sharing a base morpheme, a claim sometimes made for English (e.g., Kempley & Morton, 1982)—then priming should have been equal among all inflected forms. Counter to the claim of a homogeneous representation, identity primes and morphologically related primes were not equally effective for all targets. In summary, the pattern of partial facilitation obtained in Experiment 2 argues against a uniformly coherent noun system. Moreover, the observed asymmetry in the facilitation among entries of an inflected noun system can be interpreted to support the alleged special status of the nominative singular case proposed by the satellite-entries account.

The effect of presenting a morphologically related word prior to the presentation of a target word was significantly greater than the analogous manipulation on pseudowords. However, the small, but nevertheless significant, effect of repetition on inflected pseudowords in Experiment 2 implicates a nonlexical contribution to facilitation in the repetition priming paradigm. The nature of inflectional

processes in Serbo-Croatian guarantees that members of a satellite system generally will be both orthographically and phonologically very similar. Consequently, all morphologically related prime-target pairs were visually and phonologically similar in their initial portion. The third and final experiment was designed to examine appreciation of morphological relatedness in word pairs, with diminished orthographic and phonological similarity.

### EXPERIMENT 3

In Experiment 3, we asked whether nouns that include sound and spelling changes in some of their inflected forms are represented in the lexicon by a satellite constellation. The present experiment included nouns with two types of sound and spelling changes: (1) feminine words with palatalization in their dative/locative forms and (2) masculine words with changed nominative/accusative forms that include either (a) a movable A or (b) an O which elsewhere appears as L. We will refer to morphemes that occur in more than one form as *alternating*. It is important to note that by linguistic accounts, these alternations are regular and can be described by rules, although they are no longer productive. The repetition priming paradigm was again used with nominative targets preceded by an identical prime and by two morphological primes. For half of the items presented (i.e., masculine alternating nouns such as PETAK), both morphological primes differed in spelling and pronunciation from the target forms (i.e., PETKU, PETKOM). For the other half of the items (i.e., feminine alternating nouns such as NOGA), half of the morphological primes differed in spelling and pronunciation from the target (i.e., NOZI) and half were identical in spelling and pronunciation of the stem morpheme to that of the target (i.e., NOGOM). As in previous experiments, decision latencies to targets as a function of type of prime addresses the issue of cohesion among inflected members of a noun system, and the pattern of decision latencies (and correlations) among primes hints at the structure of the noun system.

### Method

**Subjects.** Forty-two first-year students from the Department of Psychology at the University of Belgrade participated in Experiment 3. All had participated in either Experiment 1 or Experiment 2 approximately 6–8 weeks earlier.

**Stimulus materials.** Twenty-one alternating masculine words and 21 alternating feminine words were included in Experiment 3. All of the masculine words had changed spellings in the nominative/accusative singular case; this case constituted the atypical form. For most masculine items, the alternation took the form of the addition of a vowel before the last consonant of the base form, thus eliminating certain consonant sequences in word-final position that occurred as a consequence of the disappearance of a weak semi-vowel in word-final position (e.g., PETAK vs. PETKU [nominative singular vs. dative singular]). For other masculine forms, the alternation involved the deletion of L and its replacement by O in syllable- and word-final position (e.g., PETAO vs. PETLU [nominative/accusative vs. dative/locative singular]); this development

Table 4  
Examples of Alternating Masculine and  
Feminine Singular Inflected Nouns

Case	Masculine		Feminine
Nominative	PETAK*	PETAO*	NOGA
Genitive	PETKA	PETLA	NOGE
Dative	PETKU	PETLU	NOZI*
Accusative	PETAK*	PETAO*	NOGU
Instrumental	PETKOM	PETLOM	NOGOM
Locative	PETKU	PETLU	NOZI*
Vocative	PETCE	PETLE	NOGO

\*Atypical form.

occurred in 14th-century Serbo-Croatian and, again, it was related to the disappearance of a weak semivowel following syllable-final L (Belić, 1976). In each case, nominative/accusative and dative/locative forms contained the same number of letters.

All of the feminine words had changed spellings in the dative/locative form where the alternation entailed palatalization of velar consonants (i.e., the consonants K, G, H change to C, Z, S when followed by I derived from "o: or the letter jot [second palatalization]" [Belić, 1976]). By comparison, the instrumental singular forms for both masculine and feminine words were typical in construction. One consequence of the locus of the changed case form was that for masculine words the dative/locative and instrumental forms shared spelling and pronunciation, whereas for feminine words the nominative and instrumental forms were similar. Masculine and feminine pseudowords were constructed to include the same style of spelling and sound changes that occurred in words. Examples of alternating masculine and feminine words in their inflected case forms are presented in Table 4.

The test order and composition of the list(s) were analogous with those of Experiment 1. In the present experiment, target words were presented in nominative case and all items were printed in roman script. As in previous experiments, lags between target and prime averaged 10 items with a range of 7 to 13. With the exception of the number of words in a test order, the testing procedure was identical to that described above.

## Results

Errors and extreme response times were eliminated from the present analyses according to the same criteria applied in the two previous experiments. Fewer than 3% of all responses were eliminated according to these criteria. An additional 2% of all responses was eliminated by the error-pairing procedure. Table 5 summarizes the mean

Table 5  
Mean Reaction Times (in Milliseconds) to Nominative Targets  
(NN, DN, IN) With Sound and Spelling Alternations and to  
Their Nominative, Dative/Locative, and Instrumental  
Primes (N1, D1, I1) in Experiment 3

Masculine		Feminine		Combined							
Prime	Target	Prime	Target	Prime	Target						
Words											
N1	664*	NN	631	N1	706	NN	622	N1	685	NN	627
D1	728	DN	641	D1	785*	DN	634	D1	757	DN	638
I1	726	IN	633	I1	739	IN	631	I1	732	IN	632
Pseudowords											
N1	771*	NN	744	N1	773	NN	765	N1	772	NN	754
D1	758	DN	741	D1	796*	DN	777	D1	777	DN	759
I1	806	IN	750	I1	816	IN	757	I1	811	IN	753

\*Form that undergoes sound and spelling change.

recognition times for nominative targets of alternating words and pseudowords.

Analyses of variance with prime condition (N1, NN, DN, IN) and gender as independent variables were performed on real-word latencies using subjects and items as random variables. Consistent with the outcome for repetition priming of nominative targets for regular words, there was a significant effect of prime condition [ $F_1(3,123) = 37.30$ ,  $MSe = 1,630$ ,  $p < .001$ ;  $F_2(3,120) = 19.57$ ,  $MSe = 1,553$ ,  $p < .001$ ]. The interaction of gender  $\times$  prime condition was also significant [ $F_1(3,123) = 10.38$ ,  $MSe = 1,191$ ,  $p < .001$ ;  $F_2(3,120) = 3.98$ ,  $MSe = 1,553$ ,  $p < .01$ ]. All feminine targets showed more facilitation relative to unprimed nominatives (N1) than did masculine targets. In subanalyses including only target word latencies (viz., NN, DN, IN), neither the effect of gender nor the effect of prime condition approached significance.

An analogous analysis of pseudoword latencies indicated a significant effect of prime condition [ $F_1(3,123) = 3.44$ ,  $MSe = 1,775$ ,  $p < .02$ ], a significant effect of gender [ $F_1(1,41) = 8.98$ ,  $MSe = 2,481$ ,  $p < .005$ ], and an interaction of condition  $\times$  gender [ $F_1(3,123) = 3.74$ ,  $MSe = 1,338$ ,  $p < .01$ ]. None of these was significant by the items analysis, however [ $F_2(3,120) = 1.76$ ,  $MSe = 1,739$ ,  $p < .16$ ;  $F_2(1,40) = 1.50$ ,  $MSe = 7,425$ ,  $p < .23$ ; and  $F_2(3,120) = 1.44$ ,  $MSe = 1,739$ ,  $p < .23$ , respectively].

Inspection of the latency data for word primes suggested an interesting deviation from the familiar equivalence among oblique-case latencies predicted by the satellite-entries account. Results of analyses of variance indicated a significant effect of case [ $F_1(2,82) = 41.76$ ,  $MSe = 2,654$ ,  $p < .001$ ;  $F_2(2,80) = 17.98$ ,  $MSe = 3,082$ ,  $p < .001$ ], a significant effect of gender [ $F_1(1,41) = 55.60$ ,  $MSe = 1,602$ ,  $p < .001$ ;  $F_2(1,40) = 2.77$ ,  $MSe = 16,051$ ,  $p < .01$ ], and an interaction of case  $\times$  gender [ $F_1(2,82) = 4.97$ ,  $MSe = 2,079$ ,  $p < .009$ ] that was not significant by stimulus analysis [ $F_2(2,80) = 1.68$ ,  $MSe = 3,082$ ,  $p < .19$ ]. For both genders, nominative forms were recognized most quickly. For masculine forms, oblique cases, neither of which had changed spellings, were equivalent. By contrast, for feminine forms, instrumentals, whose stem morphemes were identical in sound and spelling to those of their nominative forms, were significantly faster than dative/locative forms in which the stem morpheme was not identical [ $t(41) = 4.57$ ,  $p < .01$ ].

An analogous analysis of alternating pseudoword primes indicated that the effect of case was significant [ $F_1(2,82) = 17.36$ ,  $MSe = 2,147$ ,  $p < .001$ ;  $F_2(2,80) = 5.45$ ,  $MSe = 3,418$ ,  $p < .01$ ], as was the effect of gender [ $F_1(1,41) = 11.57$ ,  $MSe = 1,489$ ,  $p < .002$ ;  $F_2(1,41) = 11.57$ ,  $MSe = 1,489$ ,  $p < .002$ ]. The interaction of case  $\times$  gender was also significant [ $F_1(2,82) = 3.12$ ,  $MSe = 2,400$ ,  $p < .05$ ;  $F_2(2,82) = 3.12$ ,  $MSe = 2,400$ ,  $p < .05$ ].

No analyses were performed on the error data because some subjects made no errors and all subjects tended to

be extremely accurate. Out of 14 possible errors per condition, the mean number of errors in Conditions N1, D1, and I1 for words and pseudowords, respectively, were .63, 1.04, and .85 and .65, .42, and .69. The mean number of errors on targets in each condition (NN, DN, IN), computed independently of the error-pairing procedure, was less than .20 for both words and pseudowords.

Finally, means for prime words in each inflected case were computed and correlated, with nominative-dative, nominative-instrumental, and dative-instrumental latencies grouped as pairs. Because there was a case  $\times$  gender interaction among primes, separate correlations were made for feminine and for masculine word pairs. The correlations of N1,D1, N1,I1, and D1,I1 were  $r = .38$ ,  $r = .77$ , and  $r = .22$ , respectively, for feminine words and  $r = .69$ ,  $r = .77$ , and  $r = .82$ , respectively, for masculine words. No analogous pseudoword correlations approached significance. With 21 words (and  $df = 19$ ) correlations of  $r = |.44|$  are significant at the .05 level. In summary, with the exception of correlations involving feminine dative/locative case, correlations among all inflected forms of a noun were significant.

### Discussion

Differences between prime and target in spelling and pronunciation of the shared morpheme did not eliminate the effect of repetition. Facilitation with repetition obtained both when target and prime maintained a common spelling and pronunciation and when they did not. This outcome is consistent with that obtained by Fowler et al. (1985), which showed statistically full priming for alternating English words, and also with many of the results reported by Stanners et al. (1979). It is not the same, however, as the outcome of an experiment by Kempley and Morton (1982) in which irregular morphologically related words were presented auditorily for recognition in noise, and in which no priming obtained between irregular and regular forms. Evidently, the outcome of the present study indicates that regular alternations in sound and spelling do not mask morphological relationships. Treating the identity prime condition (NN) as a baseline, there was no significant reduction in facilitation due to repetition when morphological primes differed from targets in spelling and pronunciation (viz., dative and instrumental masculine primes and dative feminine primes). Statistically, priming was full in all instances. Secondly, and as described above, Fowler et al. (1985) reported that a nonsignificant numerical loss in priming typically occurs when affixes of prime and target are not identical. Results of an analysis of target latencies alone in the present experiment replicates the outcome of Fowler and her colleagues in a study of English. There is a tendency for prime target pairs with nonidentical affixes to show very small and nonsignificant reductions in the magnitude of facilitation. Based on these data, overlap in sound and spelling between target and prime (interpreted as a nonlexical or an episodic contribution) did not systematically modify the facilitation that occurs in the repetition priming task.

The coherence among satellite entries of alternating nouns appears not to differ from that of nonalternating nouns.

Among pseudowords, inspection of means suggested that the magnitude of facilitation averaged over gender was 18 msec when prime and target differed (Experiment 3) and was 58 msec in one condition when prime and target remained the same (i.e., for feminine pseudowords in Experiment 1). In Experiment 3, the analyses of variance were significant only by the subjects analysis, and in Experiment 1, there was no facilitation with repetition for masculine pseudowords. Nevertheless, it is important to point out that the differences among latencies to pseudoword targets cannot readily be ascribed to overlap of surface characteristics for target and prime. Inspection of means suggested that, irrespective of case of prime and in contrast to the outcome of Experiment 1, alternating masculine pseudoword targets were primed more consistently than were alternating feminine pseudoword targets. However, morphological primes were consistently less similar to their targets for masculine pseudowords (whose nominative/accusative was different from all oblique forms) than for feminine pseudowords (whose nominative overlapped formally with instrumental morphological primes but not with dative morphological primes). In summary, the magnitude of facilitation was significantly reduced in alternating pseudoword targets relative to that in regular pseudoword targets, but similarities of surface characteristics do not account satisfactorily for the pattern.

For alternating primes, the interaction of case  $\times$  gender and the pattern of correlations among recognition latencies indicated that the structure of the noun system for masculine and for feminine nouns contrasts. Latencies for masculine nouns supported the usual primacy for the nominative and the equivalence among oblique cases described by a satellite-entries account, whereas latencies for feminine nouns suggested that recognition of the dative/locative was impeded because its spelling and pronunciation were different from its nominative and other oblique cases. This outcome suggests that at least for feminine alternating nouns the structure of the noun system may differ from the typical satellite configuration. Pairwise correlations between mean latencies for each word in its nominative, dative/locative, and instrumental forms supported this interpretation. For masculine nouns, all cases were strongly correlated, whereas for feminine nouns, the changed dative/locative form did not correlate significantly with its more regular forms, although the regular cases did correlate with each other.

In summary, deviations in spelling and pronunciation affect the structure of the inflected noun system as evidenced by latencies for changed dative/locative forms of feminine alternating nouns that served as primes. The failure to demonstrate an analogous effect in masculine nouns was ambiguous, however. It might reflect a qualitative difference in the irregular spellings. The phonetic environment for the application of the movable A rule or the O-to-L alternation is perhaps less simply described



than is the environment for palatalization. Alternatively, this failure may provide further evidence for the primacy of the nominative case. If typicality within a satellite system is defined relative to the nominative form, then changed nominative forms of alternating masculine nouns may not, in effect, be deviant. The pattern of correlations supports the latter interpretation.

In conclusion, the latency data for changed primes suggested that deviation in spelling and pronunciation alter initial accessibility of inflected forms and the structure of the noun system, whereas the repetition priming data on target words suggested that once an entry has been activated, the nominative nucleus of its noun system is activated as well. Deviations in spelling and pronunciation may affect the structure of the noun system; it appears, however, that once the satellite entry of either a regular or an alternating noun system has been accessed, the entire noun system is activated.

### GENERAL DISCUSSION

In Experiment 1, nouns in the nominative case were primed by identical or morphologically related forms, namely, dative/locative and instrumental cases. The outcome was statistically full facilitation by repetition in all prime conditions. This outcome is consistent with the claim that inflected-noun forms in Serbo-Croatian are strongly cohesive in the lexicon. The pattern of latencies for the primes replicated the pattern from which the satellite-entries account originated (Lukatela et al., 1980; Lukatela et al., 1978). Moreover, the latencies of primes were significantly correlated. A critical characteristic of the satellite-entries account is that the nominative singular case has a special status in the lexical organization. One consequence of its privileged position might be that the nominative can prime and be primed more fully by non-nominative cases than can any oblique case. The outcomes of Experiments 1 and 2 support this interpretation. In Experiment 1, we found full facilitation of nominative targets by both identical and morphological primes. In Experiment 2, lexical decision latency to nouns in the dative/locative case was facilitated by a prior presentation of a morphologically related inflected form. However, instrumental singular primes produced only partial facilitation of dative/locative targets. The statistically significant pattern of full and partial priming was interpreted as evidence that the lexical organization among inflected cases of a noun is not homogeneous; that is, connections among inflected nouns are not uniformly represented in the lexicon. In particular, the connection between two satellites of an entry appears to be weak relative to the connection between a satellite and the nucleus. Insofar as inhomogeneities in organization are evident, it is difficult to conceive of a representation in which all inflected forms of a noun either share a base morpheme or are fully independent lexical entries.

In Experiment 3, nouns that undergo regular sound and spelling changes in at least one of their inflected-case

forms were presented as targets in the nominative case. Decision latency was equally facilitated by a prior presentation of all morphologically related primes. Thus, the pattern of facilitation observed does not depend on maintaining phonological and orthographic similarity between prime and target: The same outcome obtained with pairs including a sound and spelling change and pairs including no change. Likewise, the pattern of facilitation with pseudowords could not be accounted for entirely by sound and spelling overlap. Collectively, the results suggest that the representation that underlies repetition priming must be sufficiently abstract to accommodate changes in the base morpheme of morphologically related words.

The effect of repetition priming was consistently more robust with words than with pseudoword targets and this outcome is interpreted as implicating, at least in part, lexical processes. Insofar as facilitation reflects activation among lexical entries, results indicate that in addition to capturing inflectional rules that are productive, these representations also encompass alternations among forms that are probably no longer productive.

Finally, the pattern of decision latencies for regular noun primes and the correlation among forms indicates that inflected forms of a noun are associated. This outcome is interpreted as reflecting the structure of the noun system. For feminine alternating nouns, however, latencies were associated only when both words had identical base morphemes. Failure to observe a significant correlation between atypical and typical forms of alternating nouns lends support to the assumption that the pattern of correlations reflects, at least in part, lexical factors. The pattern of decision latencies and correlations for masculine alternating nouns that had a changed nominative/accusative case indicated that they were handled like regular nouns: All cases were associated. This outcome permits two interpretations: Either the nominative case is special such that alternation is defined relative to the nominative or, alternatively, that the particular sound and spelling changes that appear in the present set of masculine words are different from the changes that occur in feminine words. Discussion of the specifics by which alternating inflectional forms are represented and their role in defining the satellite organization among entries should not be allowed to obscure the basic result. The outcome of the present series of experiments is consistent with the claim that inflected cases of a noun are represented fully but not independently and that morphological relatedness provides a principle of organization in the lexicon. In this respect, the present experiments conducted in the highly inflected language of Serbo-Croatian are consistent with results of repetition priming studies conducted with English materials (Fowler et al., 1985).

In summary, the present study extends the satellite-entries account of Lukatela and colleagues (Lukatela et al., 1980; Lukatela et al., 1978) in the following ways: The equivalence of decision latencies for all oblique forms observed with nonalternating nouns was not observed with feminine alternating nouns. These data, in conjunction

with the correlations between latencies for inflected-case forms, support the claim that alternating nouns do not configure in the typical satellite fashion. In the present study, the pattern of full and partial facilitation in repetition priming was deployed to probe the organization among satellite entries as a further extension of Lukatela's work. Among regular noun systems, the facilitation was always full for nominative targets, whereas facilitation was significantly diminished when an oblique-case target was preceded by a different oblique-case prime. If magnitude of facilitation can be interpreted as an index of the organization within the inflected noun system, then these results reveal inhomogeneities in the coherence of the satellite system. Specifically, the connections between two satellite entries that represent different inflected-case forms are weaker than the connection between an entry and its nucleus. In contrast, the connections between the nominative nucleus and all of its inflected-case satellites are equally strong. The latter outcome can be interpreted as further evidence for the primacy of the nominative. Finally, when typical and atypical forms of alternating nouns were presented as primes, decision latencies to nominative targets revealed a pattern of facilitation that was comparable to that reported with nonalternating nouns. This outcome, namely full facilitation, suggests that once a satellite entry is activated, then all components of its noun system are accessed, and that this is true both for alternating and nonalternating nouns. In conclusion, although the noun system of alternating and nonalternating may differ, once access to an entry occurs, it necessarily entails the activation of its entire noun system.

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