

607

## Repetition Priming Is Not Purely Episodic in Origin

Laurie B. Feldman

University of Delaware and Haskins Laboratories,  
New Haven, Connecticut

Jasmina Moskovljević

University of Belgrade, Yugoslavia

The sufficiency of similarity among surface attributes of prime-target pairs to account for the pattern of facilitation obtained in the repetition priming paradigm was evaluated. In Experiment 1, morphological primes were singular, inflected case forms of Serbo-Croatian words and visual similarity of prime and target was manipulated by alternating the two alphabets in which the Serbo-Croatian language is written. Results indicated that the magnitude of facilitation in the alphabetically alternating condition was not reduced relative to the nonalternating condition (RUPI-RUPI vs. РУПИ-РУПИ) which suggested that visual similarity is not a necessary condition for facilitation in the present task. In Experiment 2, related pairs included (a) base forms with diminutives, a class of highly productive and semantically predictable derivations marked in Serbo-Croatian by suffixes and (b) base words with morphologically unrelated monomorphemic words whose orthographic pattern encompassed the target in initial position and a sequence of letters in final position that elsewhere functions as a diminutive suffix. No facilitation of word targets by orthographically similar but morphologically unrelated primes was observed although there was a tendency toward facilitation among structurally similar pseudowords. Collectively, the experiments suggested that structural similarity of prime and target is not a sufficient condition for facilitation in the repetition priming paradigm.

Serbo-Croatian, the dominant language of Yugoslavia, possesses some special properties that create ideal conditions under which to investigate how morphological structure of words is captured in the internal lexicon of the adult reader. First, numerous inflected and derived variants are used productively in Serbo-Croatian, and their formation is complex in that there is no simple relation between form of affix and function. Typically, a word comprises a base morpheme to which may be affixed one or more derivational suffixes that modify the meaning of the base (and sometimes change its word class), as well as an inflectional suffix which serves a syntactic function. Words whose constituent structure includes a common base morpheme are morphologically related. Second, in Serbo-Croatian a simple mapping between grapheme and classical phoneme is always preserved, and many predictable alternations are represented in the orthographic form of a word. As a result, morphological relatives may have discrepant spellings if the shared morpheme undergoes a phonological change in some, but not all variants. Finally, one language is transcribed in two different alphabets, Roman and Cyrillic, and most characters are unique to their respective alphabets. Educational policy mandates that

competence in both alphabets be demonstrated by elementary school children and the prevalence of printed material in each alphabet guarantees that this competence is maintained by adults. As a result, most words in Serbo-Croatian have two printed forms that are visually quite distinct and equally familiar to the skilled reader.

One methodology for exploring the role of morphological structure in lexical organization uses a variation of the lexical decision task known as repetition priming. Accordingly, the pattern of facilitation among related forms is interpreted to reflect, at least in part, how those forms are organized in the lexicon of the user. Critics of this approach have claimed that the effect is largely episodic in origin and reflects the formation of a memory trace for the test materials (Feustel, Shiffrin, & Salasoo, 1983) or alternatively, coding fluency attributable to prior presentation of the same visual configuration (Jacoby & Brooks, 1984). Episodic memory and perceptual fluency accounts are based on the perceptual analysis of a particular visual pattern or the memory trace thereof, and collectively they can be contrasted with a lexical alternative that claims that the representations that underlie facilitation in the repetition priming task necessarily include linguistic knowledge about the meaning and constituent morpheme structure of a letter string if it is a word. In the present study, the sufficiency of the episodic perceptual fluency account of repetition priming is examined for morphologically related words in Serbo-Croatian. Before describing individual experiments, the paradigm and its various interpretations are summarized.

In the repetition priming procedure (Forbach, Stanners, & Hochhaus, 1974; Scarborough, Cortese, & Scarborough, 1977; Stanners, Neiser, Herson, & Hall, 1979) each word or pseudoword is presented twice (with a lag of intervening items) for

---

This research was supported by funds from the National Academy of Sciences and the Serbian Academy of Sciences to the first author and by National Institute of Child Health and Human Development Grants HD-01994 to Haskins Laboratories and HD-08495 to the University of Belgrade.

Special thanks to Georgije Lukatela and the staff of the Laboratory of Experimental Psychology at the University of Belgrade.

Correspondence concerning this article should be addressed to Laurie B. Feldman, Haskins Laboratories, 270 Crown Street, New Haven, Connecticut 06511.

a lexical decision judgment. The reduction in decision latency relative to a first presentation or facilitation attributable to repetition is measured. (The first presentation of the item is the *prime*; the second presentation is the *target*.) For facilitation to occur with English materials, it is not necessary that the identical word be repeated as prime and target. Generally, morphologically related words, including inflections and derivations, also reduce target decision latency, sometimes as fully as an identical repetition. For example, in a recent study (Fowler, Napps, & Feldman, 1985), the inflected form *manages* and the derived form *management* both facilitated a subsequent presentation of *manage*, and decision latencies to the target when preceded by inflectionally or derivationally related words were equal to an identical presentation of "manage" (cf. Stanners et al., 1979). (The magnitude of facilitation with morphological relatives as primes is defined relative to the facilitation with an identical repetition [following Fowler et al., 1985]. The outcome is "full" repetition priming when identity and morpheme primes produce equivalent results. Priming that is significant but numerically less than full is "partial.") In addition, full repetition priming occurred when target and prime had slightly discrepant pronunciations or spellings (e.g., *health* and *heal*; Fowler et al., 1985; Hanson & Wilkenfeld, 1986). By contrast, it did not occur among morphologically unrelated words whose initial letters overlapped (e.g., *ribbon* and *rib*; Hanson & Wilkenfeld, 1986; Napps, 1985; Napps & Fowler, 1987). Results such as these support an interpretation of repetition priming effects as at least partially lexical in origin (Fowler et al., 1985; Monsell, 1985; Stanners et al., 1979) although they do not explicitly assess the nature and extent of a nonlexical or episodic component (Feustel et al., 1983) or, alternatively, of a task-dependent strategic contribution (Forster & Davis, 1984; Oliphant, 1983; Ratcliff, Hockley, & McKoon, 1985). Finally, Monsell (1985) and Ratcliff et al. (1985) have proposed that facilitation in repetition priming may comprise several factors, including a transitory component that is evident only at prime-target lags of 2 items or less, as well as a more stable lexical component that is evident at longer lags. The present discussion of repetition priming in lexical decision is restricted to studies that incorporated lags purportedly greater than the duration of any short-term component. In summary, it appears that facilitation that is due to presentation of morphological relatives reflects the influence of a lexical factor and that the difference between full and partial priming may reflect an episodic increment to the lexical effect when priming is full that is absent when priming is partial (Fowler et al., 1985). The relation between the extent to which the surface characteristics are retained and the magnitude of (partial) facilitation at lags greater than four items or 16 s has been explored systematically for words (but not pseudowords) by Kirsner and colleagues (Kirsner & Dunn, 1985) and is consistent with this characterization.

The present series of experiments was designed to probe the organization of morphologically related words in the internal lexicon of a reader of Serbo-Croatian, a language with a complex morphology. The repetition priming procedure of Stanners et al. (1979) was used to investigate the lexical organization of inflected and derived forms. In light of the confounding of lexical effects by episodic effects or perceptual analysis that may be inherent to the repetition priming paradigm, special consider-

ation is given to the nature of these factors. As we discussed earlier, one interpretation of the repetition priming procedure is that the priming is principally an effect based on the retrieval of information from specific prior episodes or perceptual identification of the same pattern in a similar format and context (Feustel et al., 1983). In Experiment 1, repetition priming among inflected forms of a noun was investigated, and visual contributions to episodic effects were eliminated by presenting the first and second occurrence of an item in different alphabets. We asked whether the effect of repetition priming was unchanged when the similarity of the surface characteristics of prime and target was eliminated: that is, whether the basis for facilitation by primes is sufficiently abstract to tolerate changes in alphabet without producing a reduction in the magnitude of facilitation attributable to repetition. In Experiment 2, the role of orthographic (and phonological) similarity between prime and target in repetition priming was investigated by comparing real derivatives (viz., diminutives) with an unrelated monomorphemic word whose initial portion was orthographically (and phonologically) similar to the target and whose final portion inappropriately suggested that it was a derived form. Taken together, these experiments attempt to find evidence that two non-lexical sources of facilitation govern the effects in repetition priming. To anticipate, effects defined neither by repetition of the same alphabetic characters (visual pattern) nor by repetition of the same "abstract" orthographic (structural) pattern can account adequately for the pattern of facilitation obtained with words in the repetition priming paradigm.

### Experiment 1

Morphologically related primes reduce decision latencies to their targets, an outcome that has been interpreted as an index of lexical organization (Fowler et al., 1985; Kempley & Morton, 1982; Stanners et al., 1979). An alternative to the lexical interpretation, derived from a slightly different paradigm and a recognition measure, emphasizes the formation of an episodic trace (Feustel et al., 1983) or of fluency of perceptual identification (Johnston, Dark, & Jacoby, 1985). Allegedly, it is the "visual characteristics of the display and the configuration of letters in the item that are probably preserved between successive presentations of a letter string." (Feustel et al., 1983, p. 344). Admittedly, in most studies that purport to explore morphological relatedness as a principle of lexical organization, related pairs of words are visually similar as well as morphologically related. One exception is a study by Morton (1979) in which the similarity of surface characteristics of words in the study and test phases was manipulated by alternating handwritten and typed presentations. Whereas the outcome of that study revealed a numerically small and statistically nonsignificant reduction in identification levels when writing style alternated relative to when it was maintained, it could be argued that the critical attributes of the handwritten and typed formats of a word are more similar than different. A second tact to reduce visual similarity has been to examine repetition priming for words that undergo changes of sound and spelling, including suppletions (e.g., *sleep-slept*; *go-went*; Feldman & Fowler, 1987; Fowler et al., 1985; Kempley & Morton, 1982; Napps, 1985). Under these conditions, facilitation is still observed, but

the magnitude of facilitation is attenuated relative to other experiments with words that do not undergo change. Insofar as the magnitude of facilitation is reduced when prime and target are less similar visually, episodic effects are implicated. Nevertheless, explicit attempts to relate visual similarity defined by extent of letter overlap of prime and target to magnitude of facilitation have not proven successful (Napps, 1985).

In general, it appears that structurally similar primes can augment overall facilitation in the repetition priming paradigm by introducing an episodic contribution, but is a nonlexical component sufficient to provide a full account? Discussion of lexical effects hinges on the assumption that words, but not pseudowords, can benefit from the contribution of lexical factors. According to a strong lexical view, evidence of facilitation with word targets and the absence of an effect with pseudoword targets is generally interpreted as evidence in favor of a lexical interpretation. Supporters of the episodic view have argued, however, that pseudowords as well as words have memory representations and that the outcome with pseudowords in this paradigm is equivocal because the tendency to respond "no" may be offset by the availability of an episodic trace that increases with multiple presentations whereas the tendency to respond "yes" is enhanced (Feustel et al., 1983). Similarly, the availability of a lexical representation or of item meaningfulness may affect perceptual identification so that the interdependence of performance measures on fluency and recognition tasks is greater for pseudowords than it is for words (Johnston et al., 1985). In summary, to the extent that repetition effects occur with pseudowords—an effect that is taken to be nonlexical in nature—an interpretation of the effect with words as purely lexical in origin is not supported. Nevertheless, lexical information appears to facilitate or alternatively impair the formation or utilization of nonlexical codes in repetition priming and related tasks.

In the first experiment, the contribution of visual similarity between prime and target was investigated in an attempt to identify nonlexical contributions, defined on visual characteristics of the display. Morphologically related prime-target pairs were inflected case forms of masculine and feminine nouns in Serbo-Croatian. As we noted earlier, the Serbo-Croatian language possesses a special property permitting an experimental manipulation that minimizes the visual overlap of target and prime: Words may be printed in either Roman or Cyrillic alphabet characters where the two forms are generally quite dissimilar in appearance and skilled readers are equally facile with both systems. In Experiment 1A, reported as Experiment 2 in Feldman and Fowler (1987), both targets and primes were printed in Roman script. In Experiment 1B, the same targets were again printed in Roman but the preceding primes were printed in Cyrillic. Replication of an experiment within one alphabet context and across alternating alphabet contexts permitted an evaluation of whether the visual similarity of surface attributes of target and prime necessarily figures in the magnitude of facilitation demonstrated in the repetition priming paradigm.

### Method

**Subjects.** Subjects in Experiment 1A were 39 first-year students from the Department of Psychology at the University of Belgrade. Sub-

Table 1  
*Examples of Regular Masculine and Feminine Singular Inflected Nouns Printed in Roman and Cyrillic*

Inflected case	Masculine		Feminine	
	Roman	Cyrillic	Roman	Cyrillic
Nominative	DINAR	ДИНАР	RUPA	РУПА
Genitive	DINARA	ДИНАРА	RUPE	РУПЕ
Dative	DINARU	ДИНАРУ	RUPI	РУПИ
Accusative	DINAR	ДИНАР	RUPU	РУПУ
Instrumental	DINAROM	ДИНАРОМ	RUPOM	РУПОМ
Locative	DINARU	ДИНАРУ	RUPI	РУПИ
Vocative	DINARE	ДИНАРЕ	RUPO	РУПО

jects in Experiment 1B were 48 second-year students from the same department. All were native speakers of Serbo-Croatian and fluent readers of both the Roman and Cyrillic alphabets<sup>1</sup> with normal or corrected-to-normal vision. No subject participated in more than one experiment, although all had prior experience in other reaction time studies during their first year of study at the University.

**Stimuli.** Each part of Experiment 1 included 24 Serbo-Croatian words and 24 pseudowords. Words were familiar nouns that contained four or five letters in their nominative form. Half were feminine and half were masculine. No words were included that contained sequences of more than two consonants. Pseudowords were generated by changing one or two letters (vowel with vowel or consonant with consonant) in other real words with the same orthographic structure. The same words and pseudowords were used in Experiments 1A and 1B.

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

In Experiment 1A, all letter strings were printed in Roman characters. In Experiment 1B, prime items were printed in Cyrillic characters and target items were printed in Roman. Stimulus items were selected to maximize the visual distinctiveness of Roman and Cyrillic transcriptions by avoiding those words that predominated in phonemes that had a common graphemic form in the two alphabets. For example, the word RUPA-РУПА was included but JAJE-JAJA was not. (Here, the first transcription of the word is in Roman and the second is in Cyrillic.)

<sup>1</sup> To ensure that subjects from this population had balanced control of both alphabets, a different sample of 34 first-year students were asked to perform a lexical decision judgment on 24 words and 24 pseudowords selected from but not identical with the test materials presented in Experiment 1A and 1B. In this experiment, alphabet and lexicality were within-subjects variables. That is, each subject saw words and pseudowords printed in both Roman and Cyrillic and across groups of subjects, each word and pseudoword appeared in both alphabetic transcriptions. Mean decision latency to words in their Roman and Cyrillic forms were 646 ms and 644 ms, respectively. For pseudowords, the latencies were 693 ms and 698 ms. The effect of alphabet did not approach significance for words  $F_1(1, 33) = .08, MS_e = 792.98, p < 1.0; F_2(1, 23) = .04, MS_e = 2,516.14, p < 1.0$ , nor for pseudowords,  $F_1(1, 33) = .6, MS_e = 558.29, p < 1.0; F_2(1, 23) = .11, MS_e = 3,642.44, p < 1.0$ . This outcome supports the claim that our population of skilled readers of Serbo-Croatian are equally facile in Roman and Cyrillic, and it legitimizes the appropriateness of comparisons across alphabets.

**Procedure.** Subjects performed a lexical decision task. As each letter string appeared, they had to press a telegraph key with both hands to indicate whether or not it was a word. They pressed the farther key to signal yes and the closer key to signal no. All letter strings were typed and then photographed and mounted as slides. The stimuli were projected from a carousel projection and displayed on a screen until after subjects responded (approximately 750 ms). A dark field immediately preceded and followed the display. Reaction times were measured from the onset of the stimulus display. The interval between experimental trials was controlled by the experimenter and averaged about 2,000 ms.

**Design.** In each part of the experiment, three test orders containing 100 items were created: 48 primes, 48 targets, and 4 filler items. Words and pseudowords were equally represented in each category. Test orders included three prime conditions distinguished by the inflectional case of the prime, that is, nominative, dative/locative, or instrumental. (Case of prime was indicated as N1, D1, or I1, respectively.) All targets were in dative/locative case. Half were masculine and half were feminine. (The conditions of dative/locative targets preceded by nominative, dative/locative, and instrumental primes was indicated as ND, DD, and ID, respectively.) Words appeared in the same serial position across all test orders, but the inflectional case of the prime varied. For example, the word RUP1 (meaning *hole*) was presented in its dative/locative form as the target in all three test orders but within each test order it was preceded, in the same position, by either RUPA, RUP1, or RUPOM as a prime.

Each subject viewed one test order. Therefore, each subject saw every 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. Lags ranged from 7 to 13 and were binominally distributed around a lag of 10. 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 or pseudoword in dative/locative 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. In Experiment 1A, primes and targets were printed in Roman script. In Experiment 1B, primes were printed in Cyrillic and targets were printed in Roman.

## Results

Errors and extreme response times (greater than 1,200 ms or less than 350 ms) were eliminated 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 analysis. The error-pairing procedure eliminated an additional 3% of all responses. Table 2 summarizes the mean recognition times over subjects for dative-locative target words and pseudowords in Experiments 1A (nonalternating) and 1B (alternating). They are discussed in that order. It also includes two measures of facilitation based on (a) the difference in reaction time to first and second presentation of dative/locative forms D1 - DD (b) that difference expressed as a percentage of D1 latency.

Analyses of variance on Roman-Roman pairs with condition (D1, ND, DD, ID) and gender as independent variables were performed using subjects ( $F_1$ ) and items ( $F_2$ ) as random variables. The outcome reported previously (Feldman & Fowler, 1987; Feldman & Turvey, 1983a) showed that the effect of condition was significant for real words,  $F_1(3, 114) = 59.48$ ,

Table 2

*Mean Reaction Times (RTs; in Milliseconds) to Roman Alphabet Dative/Locative Targets and Their Alphabetically Alternating and Nonalternating Dative/Locative Prime*

Prime	Condition				Facilitation	
	D1	ND	DD <sup>a</sup>	ID	D1 - DD	% <sup>b</sup>
Nonalternating	RUP1	RUPA	RUP1	RUPOM		
Alternating	РУП1	РУПА	РУП1	РУПОМ		
Target		RUP1	RUP1	RUP1		
RT to words						
Nonalternating	642	563	552	573	90	14
Alternating	678	595	588	607	90	13
RT to pseudowords						
Nonalternating	716	688	684	705	32	4
Alternating	736	712	701	705	32	5

Note. D1 = dative/locative prime; ND = dative/locative target preceded by nominative prime; DD = dative/locative target preceded by dative/locative prime; ID = dative/locative target preceded by instrumental prime.

<sup>a</sup> Identity prime condition. <sup>b</sup> (D1 - DD)/D1.

$MS_e = 2,158$ ,  $p < .001$ ;  $F_2(3, 66) = 27.54$ ,  $MS_e = 1,435$ ,  $p < .001$ . The effect of gender and the interaction of condition by gender were significant in the analysis by subjects but not in the analysis by items,  $F_1(1, 38) = 6.27$ ,  $MS_e = 1,728$ ,  $p < .02$ , and  $F_1(3, 114) = 2.98$ ,  $MS_e = 1,913$ ,  $p < .04$ , respectively.

A subsequent set of analyses including only dative/locative target latencies (Conditions ND, DD, and ID) revealed a significant effect of prime condition,  $F_1(2, 76) = 4.02$ ,  $MS_e = 2,028$ ,  $p < .02$ ;  $F_2(2, 44) = 3.17$ ,  $MS_e = 790$ ,  $p < .05$ , and inspection of means indicated that identity primes were more effective than instrumental primes. There was also a suggestion that the effect of gender was significant,  $F_1(1, 38) = 20.77$ ,  $p < .001$  (i.e., significant by the subject's analysis but not by the item's analysis). The interaction of condition by gender was not significant.

An analysis of pseudoword latencies (D1, ND, DD, ID) showed a significant effect of prime condition,  $F_1(3, 114) = 6.77$ ,  $MS_e = 2,582$ ,  $p < .001$ ;  $F_2(3, 66) = 2.75$ ,  $MS_e = 1,952$ ,  $p < .05$ , but no effect of gender and no interaction of condition by gender. A subsequent analysis of pseudoword targets (ND, DD, ID) suggested a significant effect of condition such that instrumental case primes facilitated less than did dative/locative or nominative case primes,  $F_1(2, 76) = 3.37$ ,  $MS_e = 2,848$ ,  $p < .04$ . This effect was not significant in the stimulus analysis, however. When words and pseudoword latencies were entered into one analysis, the interaction of condition by lexicality was significant,  $F_1(3, 114) = 15.72$ ,  $MS_e = 1,938$ ,  $p < .001$ ;  $F_2(3, 132) = 4.81$ ,  $MS_e = 1,950$ ,  $p < .003$ . Inspection of means indicated that words were facilitated more by repetition than were pseudowords.

When primes were printed in Cyrillic characters and dative/locative targets (real words) were printed in Roman characters (Experiment 1B), an analysis of target latencies (D1, ND, DD, ID) indicated that the main effect of condition was significant thus replicating the outcome of Experiment 1A,  $F_1(3, 141) = 54.15$ ,  $MS_e = 3,033$ ,  $p < .001$ ;  $F_2(3, 66) = 36.94$ ,  $MS_e = 1,112$ ,

$p < .001$ , both in magnitude as well as in pattern of the significance of its main effects. The effect of gender and the interaction of gender by prime condition were not significant by either analysis in Experiment 1B. As in Experiment 1A, subanalyses on target words alone (conditions ND, DD, ID) and inspection of means replicated a significant effect of case of prime,  $F_1(2, 94) = 3.88$ ,  $MS_e = 2,241$ ,  $p < .02$ ;  $F_2(2, 44) = 3.14$ ,  $MS_e = 692$ ,  $p < .05$ , whereby identity primes produced faster recognition times for dative/locative targets than did instrumental primes.

An analysis of pseudoword latencies in Experiment 1B replicated the outcome of Experiment 1A. There was a significant effect of condition,  $F_1(3, 141) = 7.60$ ,  $MS_e = 3,170$ ,  $p < .001$ ;  $F_2(3, 66) = 29.71$ ,  $MS_e = 1,382$ ,  $p < .001$ . No other main effect nor interaction approached significance. In contrast to Experiment 1A, however, a subanalysis of pseudoword targets indicated no significant difference among targets as a function of inflectional case of prime. When words and pseudoword latencies were entered into one analysis, the interaction of condition by lexicality was significant,  $F_1(3, 141) = 13.61$ ,  $MS_e = 2,553$ ,  $p < .001$ ;  $F_2(3, 132) = 5.53$ ,  $MS_e = 1,572$ ,  $p < .001$ . Words were facilitated more by repetition than were pseudowords.

### Discussion

The major outcome of the present experiment was that the magnitude of facilitation in the repetition priming procedure with inflected forms of words and pseudowords was as large when target and prime were printed in different alphabets as when they were printed repeatedly in one. In fact, the magnitudes of priming in the ID, DD, and ND conditions as assessed by subtracting D1 times from them are remarkably similar.

As we noted earlier facilitation was assessed by comparing second presentations of dative/locative case nouns printed in Roman characters (ND, DD, IN) with the first presentations of those same items (D1) printed in either Roman (nonalternating Experiment 1A) or Cyrillic (alternating Experiment 1B). In asserting the appropriateness of a baseline that varies with respect to alphabet, note that, based on latency measures in a lexical decision task, skilled readers of Serbo-Croatian show no systematic alphabet bias for phonologically unambiguous words. This outcome, namely, equivalent reaction times to the Roman and Cyrillic transcriptions of a letterstring, has been reported both in designs where alphabet is treated as a between-subjects (Feldman & Turvey, 1983b) and as a within-subjects variable (see Footnote 1).

The visual overlap of target and prime is allegedly an essential condition for nonlexical facilitation. If the effects in repetition priming were predominantly episodic in origin in the sense that proponents of the episodic view have claimed, then two appearances of the same orthographic configuration in a repetition priming task should have facilitated recognition more than two presentations in different alphabet transcriptions. In the present experiment, it did not. The identity prime condition (D1 – DD) produced 90 ms of facilitation both when the same visual pattern was repeated (by using Roman characters throughout, viz., in Experiment 1A) and when the visual pattern was not repeated (because primes were in Cyrillic print and targets were in Roman, viz., in Experiment 1B). Likewise for pseudowords, whether prime and target were alphabetically nonalternating or

alternating, the effect of condition (D1, DN, DD, ID) was significant by both the subjects and the items analysis of variance. Moreover, the numerical differences between D1 and DD latencies was comparable in the nonalternating and the alternating alphabet conditions (32 ms vs. 35 ms). With respect to both the order of magnitude of facilitation and the reduced facilitation relative to that observed with real word targets, these results with pseudowords are consistent with those reported in other repetition priming studies that introduce a comparable range of lags (Feldman & Fowler, 1987). Although it cannot be visual in nature, the pseudoword results implicate a nonlexical source of facilitation.

Subjects in the alphabetically nonalternating condition tended to be faster overall than subjects in the alternating condition. Two plausible accounts are offered. Perhaps first-year students (nonalternating condition) were more practiced at reaction time studies than their second-year counterparts (alternating) because experimental participation is a requirement of the first-year curriculum. Alternatively, the mixed-alphabet design may have produced an overall slowing in reaction times relative to the pure alphabet design. The discrepancy attributable to alphabet makes a direct comparison of mean latencies across Experiments 1A and 1B difficult to interpret (although contrasts within an experiment are not affected). Nevertheless, magnitude of facilitation was equal in alphabetically alternating and nonalternating contexts despite the tendency for slower targets to be facilitated more in variations of the present task (Forster & Davis, 1984).<sup>2</sup> Because the range of lags was binominally distributed in the test orders, no analysis of facilitation by lag was attempted. Note that when such analyses have been reported for lexical decision with English materials and prime-target intervals of 0, 1, 3, and 10 items, the effect of lag is not significant (Napps, 1985). Nevertheless, significant facilitation has been demonstrated for alternating language conditions at an interval of 0 but not at intervals of 2 and 32 items (Kirsner, Smith, Lockhart, King, & Jain, 1984). It is conceivable, that facilitation between visually discrepant prime-target pairs may vary with a more extensive range of lags.

Under both alternating and nonalternating alphabet conditions the facilitation of word targets by identical primes was significantly greater than by morphological primes whose affixes differed from the target affix (viz., instrumental primes for dative/locative targets). Fowler et al. (1985) have proposed that the full-partial distinction in magnitude of priming reflects the decreased contribution of an episodic factor, defined by letter overlap, in the morphologically related prime condition relative to the identity prime condition. As long as "letter" is defined abstractly, the present results for words are consistent with that claim. The foregoing result was not significant for pseudowords, however. An alternative possibility, also suggested by Fowler et al., is that it reflects degree of association among words in the lexicon where morphological relatives are associated less closely than are words to themselves.

<sup>2</sup> The foregoing claim is contingent on the appropriateness of the D1 baseline under alphabetically alternating conditions, which assumes that skilled readers are equally facile with both alphabets. Under conditions of dominance in either alphabet, an alternative comparison would be required.

Insofar as changes in alphabet did not diminish the magnitude of facilitation, the basis for similarity must be more abstract than visual descriptors defined with respect to letter identity. In this respect, changes of alphabet appear similar to case alternations (Scarborough et al., 1977) and different from changes of language or modality (Kirsner et al., 1984; Scarborough, Gerard, & Cortese, 1984) in terms of the relevance of surface attributes (Jacoby & Brooks, 1984) or specificity of the representations that underlie facilitation in the present task (Kirsner & Dunn, 1985). In summary, one source of facilitation in repetition priming is necessarily more abstract than the surface characteristics of a visually presented letter string, and this factor may apply to letter strings with or without a lexical representation. On the basis of other evidence about reading processes in Serbo-Croatian, it is proposed that this code may be phonological in nature, although it must tolerate systematic phonological alternations as well (Feldman & Fowler, 1987).

The outcome of Experiment 1 indicated that visual attributes of prime and target could not account for the pattern of facilitation; however, a morphological principle was not directly assessed. In Experiment 1, all prime-target word pairs that were structurally similar necessarily shared a base morpheme. In Experiment 2, the sufficiency of nonlexical effects to account for the pattern of facilitation is investigated by comparing prime-target pairs that share extensive orthographic and phonological similarity with and without morphological relatedness.

### Experiment 2

The Serbo-Croatian language has a complex morphology which comprises many derived forms including diminutives, augmentatives, and agentives (see Table 3). Typically, derivatives are formed by appending an affix to the base form of a noun. So, for example, the word KORICA, which means thin crust, is derived from the word KORA, which means crust, and the word STANČIĆ, which means little apartment, is derived from the word STAN, which means apartment (these are feminine and masculine examples, respectively). The most common diminutive suffixes are (Č)IĆ, ICA, ENCE, and AK and they are used productively in Serbo-Croatian. As contrasted with other derived forms that do not always respect the word class of their base word (i.e., agentive words such as BAKER, a noun, derived from the verb BAKE), diminutives are more like inflections in that they entail only a slight alteration to the meaning of their base words. Thus, diminutives are classified as derivations of subjective judgment (Stevanović, 1983) and are considered almost as similar semantically to their base word as are inflections.

In the present experiment, nominative-case base words were presented as targets in a repetition priming paradigm. As in the previous experiment, they were sometimes preceded by the same word and sometimes by a morphologically related word, specifically, the diminutive of that word. In order to assess whether abstract letter or phonological similarity can account for the facilitation obtained in the repetition priming task, unrelated words that were orthographically and structurally similar to the target word were also included as primes.

Primes that are orthographically similar but morphologically unrelated to the target have been presented in previous repeti-

Table 3

*Examples of Morphologically Related Words Formed With the Base Morpheme STAN*

Example	Meaning
STAN	apartment
STANOVI <sup>a</sup>	apartment (plural)
STANČIĆ <sup>b</sup>	small apartment
STANAR <sup>b</sup>	tenant
PODSTANAR <sup>b,c</sup>	subtenant
STANARINA <sup>b</sup>	rent

*Note.* Words are in nominative singular unless otherwise noted.

<sup>a</sup> Inflectional suffix added. <sup>b</sup> Derivational suffix added. <sup>c</sup> Derivational prefix added.

tion priming studies conducted with English-language materials (Hanson & Wilkenfeld, 1986; Murrell & Morton, 1974; Napps, 1985). Typically, similarity is defined such that both the prime and target have the initial sequence of letters in common (i.e., RIBBON-RIB), but the extent of orthographic overlap is variable and the final portion of the longer word is essentially unconstrained. In the present study, each orthographically and structurally similar unrelated prime was a monomorphemic word in which the initial portion contained the full stem (base morpheme) and the final portion consisted of one of the sequence of letters (viz., (Č)IĆ, ICA, ENCE, AK) that elsewhere formed the diminutive suffix (i.e., KORAK, STANICA). These words are termed *pseudodiminutives*. In this way, the structural similarity to target words of morphologically related and unrelated primes was maximized. By one account, lexical access time depends on the time to access the base morpheme in the internal lexicon and search is conducted from most common to least common. (In this case decision latencies for pseudodiminutives might vary as a function of the frequency of the inappropriate base morpheme.)

In summary, in the present experiment the facilitative effect of diminutive and pseudodiminutive primes on lexical decision latency to base target words was investigated. We asked whether the facilitative effect for words in the repetition priming task can be attributed solely to the orthographic and phonological similarity of prime and target or alternatively, whether it necessarily reflects *morphological* relatedness as well.

### Method

*Subjects.* Subjects were 45 students enrolled in an introductory psychology course at the University of Belgrade. They received course credit for their participation and all had prior experience in reaction-time tasks.

*Stimulus.* A total of 24 nouns containing four to six letters in their nominative singular form were selected so that they met two criteria: (a) Each noun permitted a diminutive derivation which included the stem (nominative for masculine words, nominative minus position final *A* for most feminine words) with no changes in segmental structure. (b) There existed a monomorphemic word that was orthographically similar to it in that the initial portion included the entire stem and the final portion included one of the sequences of letters (viz., (Č)IĆ, ICA, ENCE, AK) that elsewhere forms a diminutive suffix.

Consider the triples KORA, KORICA, and KORAK and STAN, STANČIĆ,

Table 4  
Mean Reaction Times (RTs; in Milliseconds)  
to Base-Word Targets

Lexicality	Condition				Facilitation	
	B1	BB	DB	PB	B1 - BB	%*
Prime Target	STAN	STAN STAN	STANČIĆ STAN	STANICA STAN		
Words	610	563	585	609	47	8
Pseudowords	750	712	723	736	38	5

Note. B1 = base prime; BB = base-word target preceded by base prime; DB = base-word target preceded by diminutive prime; PB = base-word target preceded by pseudodiminutive prime.

\* (B1 - BB)/B1.

STANICA. The first two members of each triple represent a nominative word and its diminutive derivation. They are orthographically and phonologically similar but morphologically unrelated to the last member of each triple, which is a pseudodiminutive. To reiterate, pseudodiminutive words are (a) morphologically unrelated to the target word, (b) monomorphemic in structure, but (c) appear (inappropriately) to contain a diminutive affix. KORAK and STANICA mean *step* and *station*, respectively. The mean frequency (Lukić, 1983) for base, diminutive, and pseudodiminutive words was 329.0, 16.5, and 64.0, respectively.

Nominative pseudowords were constructed according to the criteria described in Experiment 1. Diminutive pseudowords were formed by adding a real diminutive affix (viz., IČIĆ, ICA, ENCE, AK) to a pseudoword base. Pseudodiminutive items were formed by adding meaningless affixes (i.e., TRA, IZO, ITRA, AT) to pseudoword bases.

Design. Three tests orders were created according to the constraints adopted in Experiment 1. Each was composed of 24 target words and 24 target pseudowords, which were preceded 7 to 13 items earlier in the order by their primes. Equal numbers of (nonderived) nominatives, diminutives, and pseudodiminutives served as primes in each test order. Test orders were distinguished by the form of the primes: base, diminutive, or pseudodiminutive (indicated as B1, D1, or P1, respectively). For both words and pseudowords, items were always in nominative case. (The conditions of nominative case base word preceded by base, diminutive, and pseudodiminutive primes were indicated as BB, DB, and PD, respectively.) Words appeared in the same serial position across all test orders and the form of the prime varied.

To summarize the experimental design, across test orders each target word in its base form was preceded by its prime in base, diminutive, or pseudodiminutive form. Within each order, a stem occurred once in a target and once in a prime and case of prime varied with item.

## Results

Incorrect responses and extreme scores (greater than 1,250 ms or less than 350 ms) were eliminated from all analyses. These criteria eliminated 2% of all responses. The error pairing procedure eliminated another 2% of all responses. Results of an analysis of variance on current responses to target words (B1, BB, DB, PB) indicated a significant effect of condition by both the subjects  $F_1$  and stimuli ( $F_2$ ) analyses,  $F_1(3, 132) = 16.38$ ,  $MS_e = 1377$ ,  $p < .001$ ;  $F_2(3, 69) = 7.82$ ,  $MS_e = 1538$ ,  $p < .001$ . Inspection of mean latencies by condition (see Table 4) indicated no facilitation for target words preceded by pseudodiminutives and significant facilitation for targets preceded by identi-

cal and diminutive primes. A protected  $t$  test (Cohen & Cohen, 1975) indicated that targets preceding identical primes were faster than by diminutive primes  $t(44) = 2.9$ ,  $p < .01$ .

Mean reaction time for word primes followed the pattern predicted by their respective frequencies such that base forms were faster than pseudodiminutives, which in turn were faster than diminutives. In order to explore the relation between latencies for the three cases of prime, mean decision latency was computed for each word in its base, diminutive, and pseudodiminutive form, and correlations were run on means for each pair of cases. For base-diminutive, base-pseudodiminutive, and diminutive-pseudodiminutive pairs,  $r = .30$ ,  $r = -.01$ ,  $r = -.08$ , respectively. Finally, in order to determine whether frequency of the base form influenced decision latency for derived or pseudo-derived forms, diminutives and pseudodiminutives were split dichotomously according to the frequency of their base form. Latencies for diminutives but not for pseudodiminutives followed base form frequency. Diminutive and pseudodiminutive reaction times for high- and low-frequency base words are reported in Table 5.

For pseudoword targets (B1, BB, DB, PB), the effect of condition was significant,  $F_1(3, 132) = 7.41$ ,  $MS_e = 1,619$ ,  $p < .001$ , by the subjects analysis but not by the items analysis,  $F_2(3, 92) = 1.47$ ,  $MS_e = 4,336$ ,  $p < .23$ . For pseudoword primes (B1, D1, P1), the effect of case was significant by the subjects analysis,  $F_1(2, 88) = 8.98$ ,  $MS_e = 2,449$ ,  $p < .001$ , but not by the items analysis. None of the pseudoword correlations reached significance.

## Discussion

The most important outcome of Experiment 2 was that significant facilitation occurred for words in a repetition priming paradigm only when prime and target were morphologically related. Elsewhere, the same pattern has been interpreted as reflecting, at least in part, a morphological principle of organization in the internal lexicon of the skilled reader (Feldman & Fowler, 1987; Fowler et al., 1985; Hanson & Wilkenfeld, 1986; Kempley & Morton, 1982). Moreover, structural similarity of the initial and final portion of prime-target pairs was not sufficient to produce even partial facilitation among word pairs. Specifically, pseudodiminutive word primes produced no facilitation (1 ms) for structurally similar but morphologically unrelated targets. This result is noteworthy because the composition of words which served as pseudodiminutive primes were visually quite similar and because they conceivably could have fostered a special strategy on the part of the subject such that sub-

Table 5  
Mean Reaction Times (RTs; in Milliseconds) to Base (B1),  
Diminutive (D1), and Pseudodiminutive (P1) Primes

Frequency of nominative	Case		
	B1 (STAN)	D1 (STANČIĆ)	P1 (STANICA)
High	560	723	717
Low	660	785	719

jects were able to predict upcoming targets. For example, given the constraints on selecting pseudodiminutive primes such as KORAK or STANICA, subjects could have anticipated KORA and STAN as targets and activated these lexical entries accordingly. This did not occur.

Although present numerically, effects of facilitation with pseudoword targets were absent statistically in Experiment 2 because of a failure to reach significance by the stimulus analysis. We chose, therefore, to interpret the results of the second experiment as failing to show facilitation with pseudowords, although in the first experiment, analogous effects with pseudowords were significant. It is possible, however, that the failure to reach significance reflects variability in the data attributable to a few atypical pseudowords. Significant facilitation with pseudoword targets has been reported previously (Experiment 1; Feldman & Fowler, 1987) and was interpreted as episodic in origin.

It has been claimed that prior to lexical access, a reader tries to parse all potentially polymorphemic words into stem and affixes and that reaction time in a lexical decision task is largely a function of isolating and identifying the appropriate lexical unit (Taft, 1979; Taft & Forster, 1975). Inspection of prime latencies for pseudodiminutive words provided no evidence that subjects inappropriately parsed these forms into stem and diminutive prior to making a lexical judgment. First, latencies for these items followed the pattern predicted by their frequency ( $B1 < P1 < D1$ ). Second, the data for pseudodiminutive words grouped by the frequency of their base forms had nearly equivalent means. Thus, they provide no evidence of slowing that is due to a frequency-sensitive search for the inappropriate nominative form in the course of lexical access.

The foregoing results are consistent with work conducted in the English language in that it is generally quite difficult to demonstrate evidence of an inappropriate morphemic parsing for real words. For this and related reasons, Caramazza and Lukatela, among others, have suggested that a reader's appreciation of morphology is represented lexically. Caramazza modeled morphological structure in terms of a shared base morpheme (Caramazza, Miceli, Silveri, & Laudanna, 1985; cf. Burani, Salmaso, & Caramazza, 1984). Alternatively, Lukatela and his colleagues posited morphological relatedness as a principle of lexical organization among complete inflected case forms in the satellite entries model (Lukatela, Gligorijević, Kostić, & Turvey, 1980; Lukatela, Mandić, Gligorijević, Kostić, & Turvey, 1978; see also Feldman, Kostić, Lukatela, & Turvey, 1983). For the present purposes, it suffices to point out that morpheme parsing prior to lexical access is not the only way to capture a reader's appreciation of morphology.

Taken together, the results of the present experiments indicate that visual similarity of prime and target is not necessary to obtain full facilitation of targets in the repetition priming task and this outcome calls into question a simple episodic or perceptual fluency account of facilitation that is based on the preservation over successive presentations of attributes that are visually similar. To tolerate changes across alphabet, a nonlexical basis of facilitation evidently needs to be defined on an abstract structure. Moreover, the availability of lexical knowledge appears to govern the potential contribution of structural similarity. When lexical information is absent (viz., pseudoword

prime-target pairs), structural similarity provides a sufficient condition for facilitation. In contrast, when lexical information is present (viz., real word prime target pairs) visual similarity is neither necessary nor sufficient for facilitation.

In conclusion, nonlexical effects defined by structural similarity appear to contribute to the pattern of facilitation in the repetition priming task but the adequacy of this account is contingent on the absence of lexical information. Generalizing over perceptual and memory tasks, we have borrowed the term *episodic* for this source of nonlexical facilitation, although it might be claimed that the results with our alphabet manipulation critically alter the character of the episodic trace. When lexical information is available, however, structural characteristics are only marginally relevant. In conclusion, episodic effects cannot account for the facilitation of word targets in the repetition priming task.

In the discussion of the role of phonological analysis in lexical access, researchers currently focus on the time course or interaction rather than on the competition between phonological and lexical codes. We believe an analogous characterization applies to the role of episodic and lexical effects, in the repetition priming task. Readers can evidently consider both nonlexical and lexical sources of similarity but neither is sufficient in itself to accommodate the accumulated body of data. Ultimately, the key is to understand how they work together so that the availability of lexical knowledge can mitigate the utility of other codes that may underlie facilitation in the repetition priming task.

## References

- Burani, C., Salmaso, D., & Caramazza, A. (1984). Morphological structure and lexical access. *Visible Language, 18*, 348-358.
- Caramazza, A., Miceli, G., Silveri, M. C., & Laudanna, A. (1985). Reading mechanisms and the organization of the lexicon: Evidence from acquired dyslexia. *Cognitive Neuropsychology, 2*, 81-114.
- Cohen, J., & Cohen, P. (1975). *Applied multiple regression/correlation analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.
- Feldman, L. B., & Fowler, C. A. (1987). The inflected noun system in Serbo-Croatian: Lexical representation of morphological structure. *Memory & Cognition, 15*, 1-12.
- Feldman, L. B., Kostić, A., Lukatela, G., & Turvey, M. T. (1983). An evaluation of the "basic orthographic syllabic structure" in a phonologically shallow orthography. *Psychological Research, 45*, 55-72.
- Feldman, L. B., & Turvey, M. T. (1983a, November). *Morphological processes in word recognition*. Paper presented at the Psychonomics Society Meeting.
- Feldman, L. B., & Turvey, M. T. (1983b). Visual word recognition in Serbo-Croatian is phonologically analytic. *Journal of Experimental Psychology: Human Perception and Performance, 9*, 288-298.
- Feustel, T. C., Shiffrin, R. M., & Salasoo, A. (1983). Episodic and lexical contributions to the repetition effect in word identification. *Journal of Experimental Psychology: General, 112*, 309-346.
- Forbach, G. B., Stanners, R. F., & Hochhaus, L. (1974). Repetition and practice effects in a lexical decision task. *Memory & Cognition, 2*, 337-339.
- Forster, K., & Davis, C. (1984). Repetition priming on a frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10*, 680-698.
- Fowler, C. A., Napps, S. E., & Feldman, L. B. (1985). Lexical entries are shared by regular, irregular, and morphologically-related words. *Memory & Cognition, 13*, 241-255.



- Hanson, V. L., & Wilkenfeld, D. (1986). Morphophonology and lexical organization in deaf readers. *Language and Speech*, 28, 269-279.
- Jacoby, L. L., & Brooks, L. R. (1984). Nonanalytic cognition: Memory, perception and concept learning. *The Psychology of Learning and Motivation*, 18, 1-46.
- Johnston, W., Dark, V., & Jacoby, L. (1985). Perceptual fluency and recognition judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 11, 3-11.
- Kempley, S. T., & Morton, J. (1982). The effects of priming with regularly and irregularly related words in auditory word recognition. *British Journal of Psychology*, 73, 441-454.
- Kirsner, K., & Dunn, J. (1985). The perceptual record: A common factor in repetition priming and attribute retention. In M. I. Posner & O. S. M. Marin (Eds.), *Attention and performance XI* (pp. 547-565). Hillsdale, NJ: Erlbaum.
- Kisner, K., & Smith, M. C., Lockhart, R. S., King, M. L., & Jain (1984). The bilingual lexicon: Language-specific units in an integrated network. *Journal of Verbal Learning and Verbal Behavior*, 23, 519-539.
- Lukatela, G., Gligorijević, B., Kostić, A., & Turvey, M. T. (1980). Representation of inflected nouns in the internal lexicon. *Memory & Cognition*, 8, 415-423.
- Lukatela, G., Mandić, Z., Gligorijević, B., Kostić, A., Savić, M., & Turvey, M. T. (1978). Lexical decision for inflected nouns. *Language and Speech*, 21, 166-173.
- Lukić, V. (1983). *Dečji Frekvencijski Rečnik*. Belgrade, Yugoslavia: Prosveta.
- Monsell, S. (1985). Repetition and the lexicon. In A. W. Ellis (Ed.), *Progress in the psychology of language* (pp. 147-195). London: Erlbaum.
- Morton, J. (1979). Facilitation in word recognition: Experiments causing change in the logogen model. In P. A. Kolers, W. E. Wrolstad, & M. Bouma (Eds.), *Processing visible language* (pp. 259-268). New York: Plenum.
- Murrell, G. A., & Morton, J. (1974). Word recognition and morphemic structure. *Journal of Experimental Psychology*, 102, 963-968.
- Napps, S. (1985). *Morphological, semantic, and formal relations among words and the organization of the mental lexicon*. Unpublished doctoral dissertation, Dartmouth College.
- Napps, S., & Fowler, C. A. (1987). The effect of orthography on the organization of the mental lexicon. *Journal of Psycholinguistic Research*, 16, 257-272.
- Oliphant, G. (1983). Repetition and recency effects in lexical memory. *Australian Journal of Psychology*, 35, 393-403.
- Ratcliff, R., Hockely, W., & McKoon, G. (1985). Components of activation: Repetition and priming effects in lexical decision and recognition. *Journal of Experimental Psychology: General*, 114, 435-450.
- Scarborough, D. L., Cortese, C., & Scarborough, H. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance*, 3, 1-17.
- Scarborough, D. L., Gerard, L., & Cortese, C. (1984). Independence of lexical access in bilingual word recognition. *Journal of Verbal Learning and Verbal Behavior*, 23, 84-89.
- Stanners, R. F., Neiser, J. J., Herson, W. P., & Hall, R. (1979). Memory representation for morphologically related words. *Journal of Verbal Learning and Verbal Behavior*, 18, 399-412.
- Stevanović, M. (1983). [Grammar of the Serbo-Croatian language]. Cetinje: Išro Obod OOUR Izdavačka Delatnost SR Crna Gora.
- Taft, M. (1979). Lexical access via an orthographic code: The basic orthographic syllable structure (BOSS). *Journal of Verbal Learning and Verbal Behavior*, 18, 21-40.
- Taft, M., & Forster, K. I. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior*, 14, 638-647.

Received January 10, 1986

Revision received August 25, 1986

Accepted September 19, 1986 ■