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CHAPTER 17

Morphological Analysis in Word Recognition

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One of the most refined techniques for investigating morphological processing in word recognition is the variant of the lexical decision task known as repetition priming (Stanners, Neiser, Hernon & Hall 1979). It provides a primary source of evidence, according to Henderson (1989), of facilitation between words formed from the same morpheme (i.e., morphological relatives). Generally, target (second presentation) decision latencies and error rates are reduced in the context of morphologically-related primes (first presentation). Words related to the target (e.g., HEALS) can be forms that are unaffixed (e.g., HEAL), inflected (e.g., HEALED) or derived (e.g., HEALER) in either the same or different modalities (e.g., print or speech) and they can be separated by as many as fifty intervening items. Effects of morphological relatedness have been observed in the lexical decision task across a variety of languages including Serbo-Croatian (Feldman & Fowler, 1987) and Hebrew (Bentin & Feldman, 1990), English (Fowler, Napps, & Feldman, 1985; Feldman, 1991) and American Sign Language (Hanson & Feldman, 1991; see also Emmorey, 1989).

In this chapter, we review evidence of morphological processing in word recognition. In the first two sections, studies of morphology that employ the repetition priming techniques are described. In section one, morphological and orthographic similarity effects are contrasted because alternative accounts of morphological effects in word recognition often minimize the role of the morpheme unit and focus on orthographic and phonological similarity of morphologically-related words. In section two, morphological effects are differentiated from effects due to semantic association, although both are based on word meaning. The repetition priming procedure is a viable tool for studying how morphological relationships among words are represented in the lexicon; however, a confounding episodic contribution to the pattern of facilitation can also occur (e.g., Feustel, Shriffrin, & Salasoo, 1983). It is important, therefore, to differentiate morphological effects from episodic and other types of facilitation and to provide converging evidence of morphological analysis from other word recognition tasks. Morphological effects have also been observed in sentence verification and oral reading tasks. For example, facilitation due to shared morphemes (and/or shared syntactic structure based on the ordering of subject, object and verb constituents) in prime and target sentences have been obtained. In section three, morphological and syntactic facilitation effects are examined in a sentence comprehension task. Finally, it is useful to

ask whether analysis of a word's constituent structure at the level of the morpheme is linked to analysis of that word at other linguistic levels. For example, the association between morphological and phonological processing in beginning readers has been examined by comparing performances on such tasks. In section four, a common underlying skill for morphological and phonological analysis is revealed.

1. Distinguishing between orthographic and morphological effects

The standard morphological formation processes in English typically entail prefixation and suffixation to a base morpheme. As a consequence, forms with a common base morpheme generally share orthographic and phonological as well as morphological structure. For regular forms, there is structural transparency (Henderson, 1989) in that related forms are structured around the same base morpheme (e.g., COMPUTE-COMPUTER). Moreover, to the extent that compositionality is present, related words will commonly also have similar meanings. Covariation of morphological and orthographic structure in related forms invites an orthographic account of the morphological effects observed in tasks such repetition priming.

In the repetition priming task, first (prime) and second (target) presentations are separated by an average of ten and sometimes as many as 50 intervening items. Target latency as a function of type of prime is examined. Changes in spelling or pronunciation tend not to significantly diminish the effect of morphological relatedness in this task so that prime-target pairs such as SLEPT-SLEEP or HEALTH-HEAL produce facilitation equivalent to SLEEP-SLEEP or HEALED-HEAL respectively (Fowler et al., 1985; Feldman & Moskovljević, 1987). Similarly, formal similarity of morphologically-unrelated prime and target (viz., phonologically and orthographically but not morphologically similar pairs such as DIET and DIE) does not result in priming at these long lags (Feldman & Moskovljević, 1987; Hanson & Wilkenfeld, 1985; Napps, 1989; Napps & Fowler, 1987). Despite an absence of effects due exclusively to spelling/pronunciation and orthographic form in the repetition priming literature, there persists a tendency to try to interpret morphological effects as effects of orthographic structure. For example, Seidenberg (1987) following Adams (1981) suggested that patterns of high and low bigram frequency could account for morphological patterning because transitional probabilities of letter sequences that straddle a (syllabic or) morphological boundary tend to be low (bigram troughs) relative to probabilities of sequences internal to a unit (cf. Rapp, 1992).

The similar response patterns for regular and irregular forms described above provide evidence against an orthographic account of morphological facilitation in repetition priming. Other morphological effects inconsistent with an orthographic account are based on (1) manipulations of alphabet and on the (2) the absence of an effect when a target is preceded by an unrelated word with a similar orthographic and morphological structure. These findings will be reviewed in the remainder of section one.

Many readers of Serbo-Croatian are fluent in both the Roman and Cyrillic alphabets. For such readers, this situation has been exploited in the study of morphological processing (Feldman & Moskovljević, 1987; Experiment 1). The rationale was that if the facilitation observed in repetition priming arises in a relatively early stage of processing and represents repeated analysis of the same orthographic pattern, then the facilitation due to morphological relatedness should differ when successive presentations of the target word alternated alphabet versus when they preserved alphabet. In that study (Feldman &

Moskovljević, 1987), lags ranged from 7 to 13 items and alphabet was manipulated between subjects so that a one alphabet (preserved) and a two alphabet (alternated) condition existed. Because it is possible that the time course of activation of visual form varies with lag (Monsell, 1985; Ratcliff, Hockley, & McKoon 1985), a second study was conducted in which alphabet was manipulated within subjects and a more expanded range of lags (3 to 20 intervening items) was included (Feldman, 1992). In both, words and pseudowords were presented twice, with a lag of intervening items. Subjects who were students at the University of Belgrade were instructed to perform a lexical decision to each letter string as it appeared. In the alternated alphabet condition, prime and target were transcribed in different alphabets (e.g., НОГА-NOGOM). In the preserved alphabet condition, prime and target were in the same alphabet (e.g., NOGA-NOGOM). Decision latencies to targets that were preceded by primes where target and prime either alternated or preserved alphabet were compared in an attempt to find evidence for facilitation based on repetitions of specific visual patterns.

Results of the two alphabet alternation experiments are summarized in Table 1. In neither experiment was the effect of alphabet (preserved/alternated) significant. Moreover, in the latter experiments, it was the case that for words, neither the effect of lag nor the interaction of alphabet by lag was significant. Stated generally, significant target facilitation occurred when primes appeared in either the same alphabet or in a different alphabet from the target and target facilitation was no greater in the alphabet preserved condition than in the alternated condition. Obviously words presented and represented in the same alphabet are more visually similar than are the Roman and Cyrillic alternatives of a word. Yet, in the repetition priming task where several items intervened between first and second presentations, no significant increment to facilitation was observed on the alphabet preserved trials relative to the alphabet alternating trials. This finding was observed at lags as short as 3 and as long as 20 items.

A second strategy for differentiating morphological and orthographic effects entailed comparing morphologically-related primes to unrelated primes that share orthographic structure. In Serbo-Croatian, it is possible to identify pairs of unrelated words that are formed around homographic base morphemes. For example, the word "BOR" in nominative singular, meaning "pine," is masculine in gender while the word "BORA," meaning wrinkle, in nominative singular is feminine. They have homographic base morphemes spelled BOR but, because of gender differences, require different sets of inflectional affixes. In a repetition priming task (Feldman & Andjelković, 1991; Experiment 3), targets (e.g., BOROVI from BOR) were preceded an average of ten items earlier in the list by an identical repetition (e.g., BOROVI), by a morphologically-related form (e.g., BOR) or by a morphologically-unrelated but homographic form (e.g., BORAMA from BORA). An analysis of variance revealed a significant effect of prime type in both reaction time and errors. Results are summarized in Table 2. Target decision latencies were 589 ms in the identity condition, 617 ms in the morphological condition and 656 ms in the orthographic condition. Decision latencies in the no prime condition were 661 ms. Target error rates were 3.3% in the identity, 4.4% in the morphological and 12.6% in the orthographic condition. Error rates in the no prime condition were 16.7%. The effect of prime type was significant with both subjects ($F1$) and item ($F2$) as random effect variables, with both reaction time and errors as dependent measures. Post-hoc tests indicated that the morphological and orthographic prime conditions were significantly different.

Table 1

Mean decision latencies (ms) and errors for words in the alphabet preserved and alphabet alternated conditions of the repetition priming task.

	First Presentation	Lag	Repetition: Alphabet Alternated	Preserved	Difference
(Feldman and Moskovljević, 1987; Experiment 1.)					
	642	10		552	90
	678	10	588		90
(Feldman, 1992; Experiment 1a)					
words	651	10		601	50
	12.7		6.6		6.1
				592	59
				7.3	5.4
		20	607		44
			4.5		8.2
				595	56
				7.3	5.4
(Feldman, 1992; Experiment 1b)					
words	628	3	562		66
	10.8		8.3		2.5
				562	66
				5.9	4.9
		10	567		61
			7.9		2.9
				573	55
				7.9	2.9

The orthographic and no prime conditions did not differ with either the reaction time or the error measure. That is, no facilitation with orthographically similar but morphologically unrelated words was observed when an average of ten items intervened between first and second presentations in a repetition priming task. These results are consistent with an earlier experiment conducted with Serbo-Croatian materials (Feldman & Moskovljević, 1987; Experiment 2) in which decision latencies for target words such as STAN meaning "APARTMENT" were reduced by the prior presentation of a derivationally-related prime such as the word STANČIĆ meaning "LITTLE APARTMENT." By contrast, the word STANICA did not reduce target latencies. Note that this word is morphologically unrelated but orthographically similar to the target, is composed of one morpheme and means "BUS STATION." In contrast to Feldman and Moskovljević (1987), in the present study, orthographic primes, as morphological primes, were morphologically complex forms consisting of a base morpheme and an inflectional affix. Nevertheless, orthographic primes were equivalent to the no prime condition. Collectively, these studies refute the hypothesis that orthographic similarity underlies morphonological facilitation in repetition priming.

Table 2

Mean reaction times and errors for targets (e.g., BOROVI) following identity, morphological and orthographic primes and for first presentations of the target in repetition priming.

Prime Type	Example	Latency	Errors
Identity	borovi	589	3.3
Morphological	bor	617	4.4
Orthographic	borama	656	16.7
First Presentation		661	16.7

In summary, relative to the no prime condition, both morphological relatives and identical repetitions facilitated target recognition. The orthographic prime condition was not significantly different from the no prime condition. Finally, and most important to the present discussion of morphological effects in repetition priming, target latencies and errors following morphological primes and orthographic primes at long lags were significantly different both in the analysis by subjects and in the analysis by items.

Orthographic and morphological primes also differentially influenced target latency when presented immediately in succession. In a traditional immediate priming task, morphological primes facilitate and orthographic primes may inhibit. However, the orthographic effect is sensitive to the density of the orthographic neighborhood of the prime (Forster, Davis, Schoknecht, & Carter, 1987) as well as the relative frequency of prime and target and the presence or absence of a mask (Segui & Grainger, 1990). For example, without a mask, lower frequency orthographic primes tend to inhibit whereas with a mask, it is the higher frequency prime that shows inhibition.

A recent report with French materials is consistent with this characterization of morphological as contrasted with orthographic primes (Grainger, Colé & Segui, 1991). In that study, masked primes consisted of morphological, orthographic or unrelated derivations of the target. Decision latencies for targets were fastest in the morphological condition (619 ms), (numerically but not statistically) slowest in the orthographic condition (653 ms) and intermediate (639 ms) in the unrelated condition. In those materials, however, orthographic primes (e.g., AFFIRMÉ-REFORMÉ) tended to be less similar to the target than were morphological primes (e.g., DEFORMÉ-REFORMÉ) and this might account for the marginally significant inhibition in the orthographic condition. Nevertheless, the critical point is that morphological primes showed facilitation whereas orthographic primes showed weak inhibition, at best, and conservatively, no difference from the unrelated condition.

A study recently completed in Serbo-Croatian replicates the difference between orthographic and morphological primes presented in immediate succession with an unmasked prime (Feldman & Andjelković, 1991). In a series of two experiments, targets consisting of morphologically-complex forms were preceded by either a morphological relative, an unrelated word formed from a homographic base morpheme or an

orthographically and morphologically unrelated word. For example, the target BOROVI was preceded by (1) BOR which is inflectionally related, (2) BORI which is not related morphologically although it is orthographically similar because its base morpheme is homographic and by (3) KRV which is unrelated along both morphological and orthographic dimensions. In one experiment (Experiment 2), primes were of higher frequency than targets. In a second (Experiment 3), primes were of lower frequency than targets. In both experiments, primes without masks were presented to university students in Belgrade for 250 ms and followed by a blank for 50 ms after which the target appeared for 1000 ms. Latencies greater than 2SD from the mean were treated as errors. Results are summarized in Tables 3 and 4.

Morphological and unrelated primes differed significantly at short lags in both experiments and this outcome replicates the morphological facilitation observed at longer lags with similar materials. When primes were less frequent than targets, significant orthographic inhibition (*F1* and *F2*) was evident in the error measure but not in the reaction time measure. This finding is consistent with the results of Segui and Grainger (1990) using morphologically simple materials and unmasked primes. When primes were more frequent than targets, orthographic inhibition was not statistically significant although the reaction time pattern was quite similar to the pattern obtained when primes were less frequent that their targets.

Table 3

Mean reaction times (and percent errors) for targets (e.g., borovi) following morphological, orthographic and unrelated primes. Primes were higher in relative frequency than their targets.

Prime Type	Example	Latency	Errors
Morphological	bor	684	24
Orthographic	borovi	754	45
Unrelated	krv	738	38

Table 4

Mean reaction times (and percent errors) for targets (e.g., bori) following morphological, orthographic and unrelated primes. Primes were lower in relative frequency than their targets.

Prime Type	Example	Latency	Errors
Morphological	borovi	687	15
Orthographic	bor	743	46
Unrelated	krv	746	30

In Italian, inhibitory effects between homographic base morphemes (e.g., FINA-FINIRE which mean "thin" in feminine singular and "to finish," respectively) have been reported in both a double lexical decision (viz., are both letter strings words?) and in a lexical decision task where prime and target are presented successively (Laudanna, Badecker, & Caramazza, 1989). Results were interpreted as evidence of inhibitory connections between homographic base morphemes in the lexicon. By this account, a differential effect of the relative frequencies of prime and target is not anticipated although it could be accommodated. More problematic is the failure to observe inhibition among homographic forms concurrent with facilitation among morphologically-related forms at longer intervals between presentations viz., at the lags incorporated into the repetition priming task. If inhibition reflects a principle of lexical organization then a justification for its sensitivity to lag is needed. Regardless of whether orthographic primes slow or impair accuracy to targets relative to unrelated primes and whether homographic base morphemes relative to other types of orthographic controls pose a special problem for the representation of morphology, it is useful to focus on the reliable facilitation obtained when items are morphologically-related as compared to either unrelated or orthographic conditions. This is true both in repetition priming with average lags of ten items and in successive priming with or without a mask.

In summary, morphologically-related words that undergo changes in spelling and/or pronunciation so that the base morpheme is partially obscured produce the same pattern of facilitation as do related forms that are structurally transparent. This finding has been observed in Serbo-Croatian (Feldman & Fowler, 1987) as well as English (Fowler et al., 1985; see also Kelliher & Henderson, 1990; Nagy, Anderson, Schommer, Scott, & Stillman, 1989) and presents a challenge for an orthographic account of facilitation in the repetition priming task. In addition, for morphologically-related prime-target pairs, the effect of presenting repetitions in the same alphabet was no different than the effect of alternating alphabet (Feldman & Moskovljević, 1987; Feldman, 1992). This outcome suggests that the basis of facilitation must be sufficiently abstract to tolerate changes in visual form introduced by manipulations of alphabet. Finally, when homographic base morphemes appeared in prime and target, facilitation was observed among forms that shared a base morpheme but not among unrelated forms. In fact, the contrast between homographic and no prime conditions sometimes revealed marginal inhibition. Evidently, morphological effects cannot be described in terms of shared orthographic structure.

2. Distinguishing between semantic and morphological effects

Related forms, by definition, share a base morpheme. Because morphemes are generally defined as units of meaning, it is plausible that morphological facilitation reflects the semantic similarity of prime and target. Linguists distinguish between two types of morphological relatives, inflections and derivations, and these forms differ with respect to the productivity of rules and the predictability of their meaning from a semantic analysis of the base and its constituents (Aronoff, 1976). Whereas inflections rarely produce new shades of meaning, derivations are much less constrained semantically and historically often change meaning once formed (e.g., TERRIFIC and TERROR). For example (from Henderson, 1985), the prefix UN typically modifies the base adjective or verb in a predictable manner (e.g., UNCLEAR, UNDRESS) but some forms are derived from obsolete or rare bases (e.g., UNKEMPT) (Lakoff, 1971; Jackendoff, 1975). Moreover, forms such as UN+base+ABLE are semantically ambiguous insofar as the prefix can

modify either the base verb (V) or the (V+ABLE) adjective (e.g., UNDOABLE may mean UNDO+ABLE or UN+DOABLE). Inconsistencies of semantic composition are obvious in semantic comparisons of base-derivation pairs such as DISCUSS-DISCUSSION, CONGREGATE-CONGREGATION and PROFESS-PROFESSION and point to the unpredictability inherent in a semantic analysis of some complex forms from their constituents.

Nevertheless, morphologically-related words tend to have similar meanings. Moreover, because semantic facilitation has been so thoroughly studied (see Neely, 1991, for a review), it is important to contrast facilitation due to morphological relatedness and to other types of semantic relatedness. Semantic contributions to the pattern of facilitation in repetition priming were explored with derivational relatives in English and in Hebrew. In a repetition priming study with English materials (Feldman, 1991), semantic overlap was first assessed by a separate group of subjects who scaled the items for semantic distance. (Due to the constraints of English, word class changes and other aspects of semantic predictability were not well controlled.) For each target, a morphological relative close and remote in meaning was selected. Small but statistically equivalent effects of the prior presentation of the same morpheme in a related word were observed for derivational relatives that were semantically close (36 ms) and semantically remote (30 ms) whereas identical presentations produced robust facilitation (93 ms). Evidently, extent of semantic overlap did not influence the pattern of facilitation in repetition priming.

In a second study (by C.A. Fowler, reported in Feldman, 1991), a target (e.g., HOT) was preceded at least ten items earlier in the list by the same item (e.g., HOT) or by a strong antonym (e.g., COLD). No facilitation was observed in the antonym condition relative to the identity and no prime (i.e., initial) conditions. In the sense that these items were highly predictable and semantically constrained, it is difficult to argue that semantic similarity underlies facilitation in repetition priming.

A third study (Bentin & Feldman, 1990) compared facilitation by associative and morphological primes at long and at short lags. Materials were Hebrew words; prime conditions consisted of morphological, semantic or both morphological and semantic relatives of the target. For example, the word meaning "LIBRARY" was preceded by the word for "NUMBER" which is formed from the same root or base morpheme, by the word for "LIBRARIAN" which is also formed from the same root and by the word for "READING" which is semantically but not morphologically related. Magnitude of morphological facilitation did not change over lags whereas that for semantic facilitation did. Moreover, when the prime immediately preceded the target, semantic and semantic-plus-morphological primes showed greater facilitation than did morphological primes but when an average of ten items intervened, morphological and semantic-plus-morphological showed equivalent facilitation. Evidently the patterns of associative and morphological facilitation are differentially affected by lag (see Table 5).

In conclusion, similarity of meaning between morphologically-related prime and target does not affect the pattern of facilitation in repetition priming. Morphological relatives closely related and remotely related semantically both produced the same pattern of facilitation at long lags. Moreover, closely related antonym pairs produced no effect under conditions where morphological relatedness effects were observed.

Table 5

Mean reaction times and errors for targets (e.g., ספרייה meaning "library") following morphological, semantic plus morphological, semantic and no prime in repetition priming (Bentin & Feldman, 1990).

			Lag			
			lag 0		lag 15	
Prime Type	Example	Meaning	RT	Errors	RT	Errors
Morphological	מספר	number	589	1.8	587	1.0
Semantic/Morphological	ספרן	librarian	559	1.0	583	2.6
Semantic	קריאה	reading	563	2.1	611	1.1
Filler			606	1.2	606	1.2

Patterns of morphological facilitation in this task are, therefore, not easily described in terms of semantic similarity. In addition, morphological effects occurred at separations between prime and target that considerably exceed those at which semantic/associative priming has been demonstrated (Bentin & Feldman, 1990; see also Dannenbring & Briand, 1982; Emmorey, 1989; Henderson, Wallis & Knight, 1984; Napps, 1989). Evidently, morphological and semantic facilitation reflect different underlying mechanisms.

3. Morphological effects in sentence contexts

The study of word recognition is sometimes represented as the interface between the domains of perception and language processing. It is the case, however, that the status of linguistic codes in word recognition is problematic (Henderson, 1989). In the first two sections of this chapter, we showed that morphological effects could be experimentally differentiated from effects of (1) shared orthographic and (2) shared semantic structure. In the next two sections, the relation between morphology and other types of linguistic patterning are examined. In section three, patterns of facilitation due to morphological and syntactic similarity between prime and target sentences are explored. In section four, the association between morphological and phonological analysis is examined in beginning readers.

Effects of morphological relatedness have been observed in sentence contexts as well as in isolated words. In one study (Feldman & Andjelković, 1990), students from the University of Belgrade were presented with pairs of sentences that either shared the same syntactic structure (subject verb (SV) or verb object (VO)) and/or shared the same base morphemes. In one experiment, subjects were required to read the sentence aloud and onset to vocalization was measured. A similar task has been reported to show effects of syntactic structure (Bock, 1986; 1990). In two related experiments, subjects were required to judge whether the sentence made sense and latency and errors were measured. For

example, subjects saw target sentences such as VODIČI PLIVAJU which means "The guides swim" and has a subject (S) verb (V) structure. Across subjects, that sentence was preceded by four types of prime sentences. These included (1) Morphologically unrelated and structurally dissimilar primes consisting of sentences such as ČITA KNJIGU which means "He reads a book." This sentence has a verb (V) object (O) structure (which is grammatical in Serbo-Croatian because pronouns need not be specified outside the verb). Also included were (2) morphologically unrelated but structurally similar primes consisting of sentences such as ŽENA ČITA which has a SV structure and means "The woman reads." and (3) morphologically related and structurally similar primes consisting of sentences such as VODIĆ PLIVA which has a SV structure and means "The guide swims." Finally, there were (4) morphologically related but structurally dissimilar primes consisting of sentences such as VODI PLIVAČA which has a VO structure and means "He guides the swimmer." Primes and targets were constructed so that the same order of the two base morphemes (i.e., VOD- and PLIV-) was maintained over all prime and target sentences in which they appeared.

Foil sentences were morphologically related or unrelated and had either the same or a different constituent structure. Morphologically related foils contained the same base morphemes in illegal combinations such as verbal affixes on nouns and nominal affixes on verbs. Morphologically unrelated foils were composed of legal morphological combinations but were semantically anomalous. The primes for foil sentences were always semantically and syntactically acceptable.

In the oral reading task, the prime and target members of a pair were presented in different alphabets. Primes were always presented in Roman and targets in Cyrillic. In this way, the visual similarity of successive presentations of a morpheme was reduced. Significant effects of morphological relatedness were observed in the oral reading task. Effects of structural similarity were absent (see Table 6). While this outcome can be interpreted as evidence of facilitation due to repetition of base morphemes in prime and target sentences, an alternative account of morphological effects in this task focuses on the repetition of the initial syllable (e.g., VOD-) in all related sentences but not in unrelated sentences. Therefore, it is important to replicate the morphological effect in a task where an advantage based on repetition of the first syllable effect seems unlikely to occur.

In the verification task, subjects had to decide whether each target sentence made sense. Therefore, latencies presumably reflect more than just processing of the first syllable. All prime sentences were meaningful as were half of the target sentences. Primes and targets were printed in the same alphabet. Otherwise, materials were identical to those of the previous experiment. Results indicated that latencies were significantly longer following morphologically unrelated primes than following morphologically related primes (see Table 6). In addition, latencies were longer following structurally dissimilar sentences than following structurally similar sentences in both the morphologically related and the unrelated conditions. The interaction was significant by *F1* but not by *F2*. As in the previous experiment, the effect of morphology could reflect priming of morphemic units over different sentence structures. Alternatively, it could simply reflect episodic repetitions of the same letter sequence (e.g., VOD-) in sentence initial position. The episodic account seems unlikely in a verification task where the entire sentence must be processed before responding. Moreover, it does not explain the significant difference between morphologically related prime sentences with same and different structures (i.e., 901 vs. 975).

Table 6

Oral reading and verification times (errors in parentheses) for target sentences primed by morphologically and structurally similar sentences (From Feldman & Andjelković, 1990).

		Sentence structure	
		Same structure	Different structure
target: VODIČI PLIVAJU (SV)			
Morphology			
	Related	VODIĆ PLIVA (SV)	VODI PLIVAČA (VO)
	Unrelated	ŽENA ČITA (SV)	ČITA KNJIGU (VO)
Task			
Oral reading:			
	Related	676	690
		(5)	(8)
	Unrelated	718	730
		(9)	(9)
Verification:			
	Related	901	975
		(3)	(16)
	Unrelated	973	1002
		(12)	(16)

In addition, when morphemes were not repeated (i.e., for morphologically unrelated sentences), structurally dissimilar primes and structurally similar primes had significantly different effects on target latencies. This outcome indicates that the verification task is sensitive to sentence structure defined over different surface forms. In summary, when the experimental task requires that the entire sentence be processed, facilitation can arise between sentences with similar structures.

An examination of the materials used in the previous two experiments revealed that morphologically related and structurally related primes consisted of words related by inflection to the target sentence whereas morphologically related but structurally dissimilar sentences generally consisted of words related to the target by derivation. In a final experiment in this study, effects of sentence structure and morphology were again investigated in a sentence verification task. In contrast to the previous experiments, here all critical items consisted of morphologically related prime-target sentences. Moreover, in addition to sentence structure, type of morphological relatedness (viz., inflection/derivation) was manipulated. The essence of stimulus construction entailed identifying base morphemes that could function as part of either a noun or a verb. For example, subjects saw target sentences (constructed around the morphemes PLIV- which means "swim" and VOD- which means "guide") such as PLIVAJU VODIČI which means "The guides swim" and has a VS structure. As in the previous experiments, that sentence was preceded by four types of prime sentences across different groups of subjects. All primes were morphologically related by either inflection or derivation to the target. In inflected sentences, the word class of the base morphemes was preserved over prime and

target sentences. In derived sentences, the word class of the base morphemes changed in prime and target sentences. In addition, primes and targets varied with respect to similarity of sentence structure. Four combinations of sentence structure and morphology were possible: (1) structurally dissimilar inflectional primes consisting of VO sentences such as PLIVA KA VODIČU which means "He swims toward the guide." (2) structurally dissimilar derivational primes consisting of VO sentences such as VODIŠ PLIVAČA which means "You guide the swimmer." (3) structurally similar inflectional primes consisting of SV sentences such as VODIĆ PLIVA which means "The guide swims" and finally, (4) structurally similar derivational primes consisting of SV sentences such as PLIVAČ VODI which means "The swimmer guides" (see Table 7). Primes and targets were constructed so that the same order of sentence constituents (viz., S,V,O) was preserved throughout a set. The advantage of constructing materials in this way is that repeated base morphemes (i.e., VOD- and PLIV-) do not always appear in the same position in prime and target sentences. For example, both VODIĆ PLIVA and PLIVAČ VODI have subject before verb but the ordering of base morphemes in these sentences differ. The disadvantage is that by preserving the ordering of elements in a pair with similar structure, the effect of changing syntactic role for a particular base morpheme may be lost. Prime and target sentences were printed in different alphabets.

Results indicated that the effect of morphology was significant (by both *F1* and *F2*) for both the latency and the error measures such that derivations produced less facilitation than did inflections. This finding suggests that the effect of sentence structure observed in the previous verification experiment can be attributed to different effects on targets of prime sentences related by inflection and by derivation. Because inflectionally related primes differed only in number from the target whereas derivationally related sentences transformed the base morpheme of the noun into a verb and the base morpheme of the verb into a noun, it was always the case that inflectional sentences were semantically more similar to the target than were derivational sentences.

Table 7

Verification times (and errors in parentheses) for target sentences primed by morphologically and structurally similar and dissimilar sentences.

	Sentence structure	
target: PLIVAJU VODIČI (VS)	Same structure	Different structure
Morphology:		
inflection	VODIĆ PLIVA (SV)	PLIVA KA VODIČU (VO)
derivation	PLIVAČ VODI (SV)	VODIŠ PLIVAČA (VO)
inflection	958	949
	(6)	(10)
derivation	1084	1100
	(20)	(21)

The effect of sentence structure was not replicated. The failure to obtain an effect of sentence structure for either inflectionally or derivationally related primes indicates that facilitation based on repetition of the initial syllable is not in itself a plausible account of facilitation. The absence of a sentence structure effect most likely reflects the way in which structure was manipulated in the present experiment. Specifically, the order of (subject, object and verb) constituents ways not always preserved across structurally related primes and their targets.

Morphological effects occur in sentence contexts as well as in isolated words. In the first two experiments in this series, all related targets started with the same initial syllable (base morpheme). Therefore, effects of morphological relatedness could simply be anticipation effects based on repetition of the first syllable. This account is not plausible in the third experiment, however. In fact, in that experiment, same structure and different structure sentences started with different initial syllables (morphemes) and yet there was no effect of sentence structure of the prime (958 ms vs. 949 ms). In sentences related by inflection, the absence of an effect of structure was not anticipated and needs to be investigated further. Specifically, in contrast to English, in Serbo-Croatian it is possible to independently manipulate repetition of sentence constituents (subject, object and verb) and the ordering of those constituents.

Even in contexts and tasks that focus on sentence processing it appears that the morphemic constituents of words are analyzed. That is, morphological analysis is not restricted to isolated words in the word recognition task. In these experiments, it is evident that activation among the morphological constituents of prime and target sentences is not necessarily tied to their syntactic role in a sentence nor to the ordering of morphemes. In the next section, associations between morphological processes and other analytic processes are investigated.

4. Associations between phonological and morphological analysis

The beginning reader provides a window through which to evaluate the relation between morphological and phonological analysis in word recognition. In one study (Feldman, Andjelković, & Fowler, in preparation), children between seven and eight years of age who were native speakers of Serbo-Croatian were administered both a morphological and a phonological task. In the morphological task, children were auditorily presented with a source word and a sentence frame and their task was to complete the sentence by adjusting the morphological affixes on the source word to make it fit semantically and syntactically with the sentence frame. Sentence frames were constructed so that depending on the source word, either an inflectional or a derivational substitution was required and frames were paired so that for one source word both an inflectional and a derivational adjustment were necessary. For example, some children were required to fit the source word KUVAR meaning "a cook" (agent in nominative singular) into the sentence frame MAMA MI POMAŽE DA ____ which means "Mother helps me to ___." This sentence requires the first person singular verb form KUVAM which is related by derivation to the source word KUVAR. For other children, the infinitive KUVATI was presented as the source word for the same sentence frame. Here the source word and the response are related by inflection. Still other groups of children viewed the same source words (i.e., KUVAR, KUVATI) on different sentence frames. For example, OVAJ RESTORAN IMA DOBROG ___ which means "This restaurant has a good___" requires the accusative singular form of the agent KUVARA. This response is inflectionally related to KUVAR and derivationally related to

KUVATI. All subjects were tested on all four combinations of sentence frame and source word and across subjects the same base morpheme appeared in all conditions. This design minimized effects due to sentence frame and to the morphological complexity and the familiarity of the source word as well as the correct response.

Thirty six sentences were constructed. Each contained between four and six words. The target word was always in final position and varied with respect to word class. Sentences were read aloud by the experimenter. The source word was presented both before and after the sentence frame and all source word-sentence frame combinations required at least one morphological substitution. Forty children randomly selected from an urban elementary school in Belgrade, Yugoslavia, were tested individually by a native speaker of Serbo-Croatian and the subjects' responses were transcribed by that experimenter. Results indicated that inflectional responses tended to be correct more frequently than were derivational responses. Mean errors were 1.0 and 3.5 respectively out of a maximum of 18.

Subsequent to the sentence completion task, all subjects participated in a phoneme deletion task (Rosner & Simon, 1971). Subjects heard words and pronounced them aloud without the designated phoneme. All words became orthographically legal but meaningless sequences after phoneme deletion. The position of the deleted letter was balanced across words and, in the source word, it always constituted part of a cluster. Responses were transcribed by the same adult native speaker of Serbo-Croatian. Performance on the phoneme deletion task was correlated with performance on the inflectional and derivational conditions (summed over sentence frame) of the sentence completion task.

Results indicated a significant correlation between phonemic deletion and each morpheme condition $r = .37$ for inflections and $r = .52$ for derivations, respectively. Finally, to each child was administered verbal and nonverbal intelligence tests and these served as covariant controls. Verbal intelligence accounted for 33% of the variance and nonverbal intelligence accounted for 25% of the variance on derivational morphology score. The contribution of intelligence to the inflectional score was not significant but this outcome may reflect the near perfect performance and consequent lack of variability on the inflectional task. Most important, results revealed a significant relationship between phonological and derivational performance even when effects of intelligence were partialled out. That is, with controls for verbal and nonverbal intelligence, performance on a phonological task was still a significant indicator of performance on a (derivational) morphology task. It accounted for a significant 14% of the variance.

Evidently, the ability to explicitly manipulate phonemic segments is associated with the ability to complete sentences with a syntactically correct form. This relationship is independent of intelligence and can be interpreted as evidence of a general linguistic style of analysis that is not tied to particular units. This outcome has also been observed for learners of English which conveys syntactic information through fixed word order in contrast to Serbo-Croatian where word order is relatively free to vary (Fowler, 1988; 1990).

It is often claimed that metalinguistic skill is the single most important factor in learning to read (e.g., Tunmer, 1988). While there is ample compelling evidence that reading an alphabetic orthography requires phoneme awareness, evidence that awareness of linguistic units above the level of the phoneme makes an independent contribution to reading skill is sparse (but see Fowler, 1988; 1990). In the present study, the awareness of morphemes in young readers is associated with phoneme awareness and the relationship cannot be explained by general intelligence or by vocabulary knowledge.

5. Morphological effects reflect linguistic analysis

It is sometimes claimed that three related skills underlie the language user's command of morphology (Tyler & Nagy, 1989). Primary is an appreciation of the *internal structure* of a word such that the presence of a shared component among morphological relatives is recognized, either explicitly or implicitly. Experimental evidence for morphological analysis of a word's structure comes primarily from patterns of facilitation in a priming task in which the same base morpheme is repeated. Recognition by skilled readers is facilitated when the same morphological components recur and the basis of this facilitation can be neither semantic nor orthographic in origin.

Once words can be analyzed with respect to morphological components then it is reasonable to ask whether skilled readers are sensitive to the constraints on *combinations* of morphemes or to the *syntactic implications* of appending particular affixes to a base morpheme. The design of the foils in the sentence verification and oral reading tasks forced adult subjects to attend to these dimensions because some sentences were composed of illegal morphological combinations. Although the foils were not analyzed, morphological analysis was evident in the facilitation to target sentences composed from the same morphological constituents as their prime sentences. Here, effects of visual similarity were eliminated by presenting members of a pair in contrasting alphabets. Interestingly, equivalent facilitation occurred when, across prime and target sentences, a base morpheme changed word class (derivational relatives) and when it did not (inflectional relatives) even though they differed with respect to semantic similarity. It has been reported that skills of morphological analysis emerge before combinatory or syntactic skills (Tyler & Nagy, 1989). In the sentence completion task, however, seven and eight year olds were able to produce the appropriate inflectional and derivation affixes for a variety of syntactic contexts. In order to respond accurately in this task, subjects had to segment the base morpheme from its source word as well as generate a syntactically appropriate affix. Sometimes this entailed forming a verb from a noun or a noun from a verb and it always required the addition of an inflectional affix. Evidently, the metalinguistic demands of this task allowed the children to utilize their knowledge of morphemes and how they combine in particular syntactic contexts.

In conclusion, evidence for morphological analysis in word recognition is not tied exclusively to the repetition priming task although that task has allowed a differentiation between morphological analysis and effects of orthographic or semantic structure. Morphological effects are also evident in a task where constituents of a sentence are experimentally manipulated. Although the mechanism of syntactic effects in the verification task is not clear, it is certain that facilitation occurs when the constituents of words are repeated. This finding is surprising because the task fosters analysis at a level more abstract than the morpheme or the combination of morphemes that comprise the words of a sentence. Evidently, readers cannot refrain from engaging in analysis at the level of the morpheme.

It has recently been demonstrated that time to recognize a target word is influenced by its frequency relative to the other words in its orthographic neighborhood (Grainger, 1990). Similarly for a morphologically simple word, the frequency of words that are inflectionally and derivationally related to it influences the pattern of reaction times in

lexical decision (Katz, Rexer, & Lukatela, 1991; Nagy, Anderson, Schommer, Scott, & Stallman, 1989; Taft & Forster, 1975) and it is not necessary that the shared base morpheme of those words be explicitly represented in the surface form (Kelliher & Henderson, 1990). These findings suggest that recognition of any particular word is influenced by properties of other words that are related along some dimension. This similarity is often captured in terms of organizational properties of the lexicon that are distributed rather than tied to one lexical entry. Perhaps the illusion of a shared orthographic or semantic component among morphological relatives has misguided the investigation of morphological processing and undermined our understanding of the status of the morpheme as an abstract linguistic unit.

It has been observed that children who are good at phonological analysis also tend to be good at morphological analysis and that their performance cannot be attributed to either verbal intelligence (and good vocabulary) or to general intelligence. This finding helps to elucidate the value of morphological analysis. It is well established that good and poor beginning readers differ in their ability to grasp the phonological structure of a word in a variety of experimental tasks. Phonological analysis helps the beginning reader map unfamiliar written words into a spoken form which may be familiar even when the written form is not. The essence of this process is an explicit appreciation of the linguistic components of a written word and how they map onto phonemes. It is important because it underlies the ability to read unfamiliar words and combinatorial productivity of the writing system in general. Morphological analysis may serve a similar function. Insofar as words can be constructed from and decomposed into meaningful components and those components can be recombined into new words, morphological analysis enhances the productivity of the reader.

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