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The contribution of morphology to word recognition

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Summary. Evidence of morphological processing was investigated in three word recognition tasks. In the first study, phonological ambiguity of the base morpheme in morphologically complex words of Serbo-Croatian was exploited in order to evaluate the claim that the base morpheme serves as the unit by which entries in the lexicon are accessed. An interaction of base morpheme ambiguity and affix characteristics was obtained and this outcome was interpreted as evidence that all morphological constituents of a word participate in lexical access. In the second study, facilitation due to morphological relatedness of prime and target was observed with Serbo-Croatian materials in the lexical decision and naming versions of the repetition priming task and results were interpreted as evidence of a morphological principle of organization among whole-word forms in the lexicon. In the third study, morphological affixes of both English and Serbo-Croatian words were segmented from a source word and affixed to a target word more rapidly than phonemically matched controls. Results suggest that the morphological constituents of complex words are available in some word recognition tasks and that morphological knowledge is represented in the speaker's lexicon.

of formation. Words that differ in their derivational affixes, but share a base morpheme (e.g., ACCOUNT, RECOUNT) are generally considered to be different lexical items and to have different meanings. Words that differ in their inflectional affixes (e.g., COUNTING, COUNTED), but share a base morpheme are generally considered to be versions of the same word, with the particular version that appears in a sentence being determined by the syntax of the sentence.

With regard to inflection, it is appealing to assume that forms are stored in terms of a base morpheme or stem and that particular inflectional variants are formed in the course of producing a sentence. The complexity of the formation rules and the unpredictability at the semantic level makes this option less plausible for derivations, however. Of course, the psychological utility of morphemes and the rules for combining them may, but need not, be consistent with the linguist's account. Morphologically complex words may be represented mentally either as whole forms or with reference to their constituents. These alternatives are not mutually exclusive (e.g., Caramazza, Laudanna, & Romani, 1988; Dell, 1987) and they may apply differently to inflectional and derivational formations.

The experimental literature on word recognition focuses on three ways in which the morphological constituents of a word may be important. These include (1) morphologically defined units for lexical access, (2) a morphological principle for organization (or representation) in the lexicon, and (3) sequencing errors in morphologically structured utterances. Models of word recognition differ with respect to the units by which a reader's knowledge about the semantic, morphemic, syntactic, phonological and orthographic properties of a word are accessed in the internal lexicon. One option, variously called the whole-word, direct-access, or addressed account, emphasizes the retrieval and match of full-word units that are unanalyzed with respect to linguistic structure. A second option is called the phonological, indirect, or assembled account. It posits that words are parsed into sublexical linguistic elements as part of the recognition process and that these units are used to search lexical memory. In addition to phono-

Introduction

Morphology, the constituent structure of words, plays a focal role both in word processing and in sentence comprehension and production. It underlies the productivity of the word-formation process and a word's fit into the syntactic frame of a sentence. In a number of languages, morphologically complex words consist of a root or base morpheme to which inflectional or derivational affixes are appended. Linguists distinguish between these two classes

logically specified units such as those deemed critical for recognition of Serbo-Croatian words (Feldman & Turvey, 1983; Lukatela, Popadić, Ognjenović, & Turvey 1980), candidates have included stems (i.e., base morpheme plus derivational affix) of morphologically complex words (Cole, Beauvillian, & Segui, 1989; Jarvella, Rob, Sandström, & Schreuder, 1987), an orthographically and morphologically defined first syllable or Basic Orthographic Syllabic Structure (i.e., BOSS) (Taft, 1979b, 1987), or a combination of whole-word and morphemic elements (e.g., Caramazza et al., 1988).

An understanding of principles of lexical organization derives principally from the lexical decision and similar tasks in which performance on a target word is improved by prior presentation of a related item or prime (Meyer, Schvaneveldt, & Ruddy, 1975; Stanners, Neiser, Herson, & Hall, 1979). In the literature, both semantic/associative and morphological principles have been identified and the latter appear to be more robust. Morphological effects between bases and both derived and inflected forms as well as their inverse (Feldman & Fowler, 1987a) persist at lags of several intervening items in repetition priming. Moreover, changes in spelling or pronunciation do not diminish the effect significantly (Feldman & Fowler, 1987a; Feldman & Moskovljević, 1987; Fowler, Napps, & Feldman, 1985; cf. Stanners et al., 1979) nor does the formal similarity of morphologically unrelated prime and target (e.g., pairs such as DIET and DIE) result in priming (Hanson & Wilkenfeld, 1985; Feldman & Moskovljević, 1987; Napps & Fowler, 1987). Finally, facilitation due to morphological relatedness as opposed to other types of semantic relatedness appears to entail distinct underlying mechanisms (Bentin & Feldman, 1990; Dannenbring & Briand, 1982; Feldman, 1991; Henderson, Wallis, & Knight, 1984). In short, the pattern of results observed with the repetition priming procedure has been interpreted as evidence that the morphological relations among words are represented in the lexicon. Although it is not without problems (see Bentin & Feldman, 1990), this outcome has been interpreted by this author in terms of a morphological principle of organization among full-word forms in the lexicon.

Another lexical alternative advocated by Caramazza and his collaborators is that lexical representations are actually decomposed into morphological constituents (Caramazza et al., 1988). Most of their work was based on lexical decision rejection latencies with Italian materials and how they were affected by a nonword's component structure. For example, nonwords composed of morphological constituents in an illegal combination are difficult to process, as is evidenced by prolonged latencies in a lexical decision task. Similar results have been observed for Italian inflectional (Caramazza et al., 1988) and English derivational (Taft & Forster, 1975) morphology. Recently, however, morphological effects have been observed between pairs of Italian words in a double lexical decision task. Specifically, performance on word pairs that were formally similar in their initial morpheme, but morphologically unrelated (i.e., the base morpheme in pairs such as PORTARE meaning "to carry" and PORTE meaning "doors" are both spelled PORT, but represent different homophonous morphemes), was impaired in relation to

control pairs defined by the similarity of their initial (non-morphemic) sequence of letters (i.e., pairs such as COLLO meaning "neck" and COLPO meaning "a blow") (Laudanna, Badecker, & Caramazza, 1989). This outcome suggests processing interference among lexically distinct, but homophonous, base morphemes and has been interpreted as evidence for morphologically decomposed lexical entries.

Finally, speech error patterns (Cutler, 1980; Fromkin, 1973; Garrett, 1980; 1982; Stemberger, 1985) provide a source of compelling evidence for morphological constituents in the production of speech. In spontaneous speech, one prevalent type of error involves a reordering of morphemic elements. Either the stem or the affix of a word may migrate from the intended word to another site. Two patterns are relevant. First, word-final elements that shift are typically morphemic elements as contrasted with phonemically equivalent, but nonmorphemic, segments. Second, inflectional suffixes are more vulnerable than derivational suffixes (Garrett, 1982). Collectively, these observations, as well as the pattern observed in some clinical populations (e.g., Badecker, Hillis, & Caramazza, 1989), indicate that the constituent structure of morphologically complex words is available to the production mechanism and that inflectional and derivational forms may be represented differently (see also Miceli & Caramazza, 1988).

In summary, recent experimental work on the psychology of morphemes centers upon effects that arise (1) preparatory to lexical access such as in the definition of units by which lexical representations can be accessed, (2) in the lexicon itself, either as a principle of lexical organization or in the representational format of lexical entries, (3) as a misordering of elements in an utterance. In the remainder of this article, three studies in Serbo-Croatian and a preliminary study in English that probe morphological effects in word recognition will be described and their relevance to issues of how morphology may contribute to word recognition will be discussed.

Interaction among morphological constituents

The first study attempts to assess the claim from English that morpheme-derived units provide the basis for lexical access (Caramazza et al., 1988; Taft & Forster, 1975; Taft, 1979a, b; 1987). According to this account, morphologically complex words are decomposed into their constituents and stripped of their affixes so that the base morpheme is the unit to which a match in the lexicon is made. Typically, recognition latencies for words are governed by the time taken to parse and evaluate the lexical status of the stem and perhaps the time taken to assess the fit of the stem with its affix. Both base morpheme or stem and whole-word frequency effects have been reported (Taft, 1979a). Of course, it is possible that whole-word effects actually reflect evaluation of the combination of base morpheme and affix combination.

The first study focuses on the phonological characteristics of the base morpheme and the experimental manipulation uses the phonological ambiguity effect (e.g., Feldman & Turvey, 1983; Lukatela et al., 1980) which is so robust

in Serbo-Croatian. Specifically, it evaluates the claim that affixes are stripped from morphologically complex words before lexical access, that the base morpheme (in isolation or with any derivational affix) provides a unit by which lexical access can succeed and that the compatibility of affix and base is checked in a later operation (Taft, 1979 a).

Critical to the phonological ambiguity manipulation is the fact that two alphabets, Roman and Cyrillic, are used interchangeably in parts of Yugoslavia. Because of the overlap between the two alphabet sets, some letter sequences can be assigned two distinct phonological interpretations, either (or both) of which can be meaningful. Moreover, all words in Serbo-Croatian can be transcribed in both alphabets and the alphabet sets are not generally mixed within a word or contiguous text. For example, the word meaning "marigold" is written NEVEN in Roman and HEBEH in Cyrillic. The former can be assigned only one phonological interpretation whereas the latter is phonologically equivocal. In the experiments on ambiguity, the difference in recognition latencies in lexical decision (or naming) to phonologically ambiguous and unequivocal forms of the same word (i.e., HEBEH minus NEVEN) provides the measure of phonological ambiguity (see Turvey, Feldman, & Lukatela, 1984).

In contrast to most work on phonological ambiguity in Serbo-Croatian, in which ambiguous forms and their unequivocal controls were generally whole-words units, in one study (Feldman, Kostić, Lukatela, & Turvey, 1983), the unit of phonological ambiguity was defined at the level of the morpheme. Experimental materials consisted of eight (four-letter feminine or neuter) nouns whose base forms, when transcribed in Cyrillic, were phonologically bivalent, but, when transcribed in Roman, were phonologically unequivocal. To each base morpheme was appended either a nominative suffix (viz., A or O), which was alphabetically (but not phonologically) bivalent in that it was pronounced and written the same way in Roman and in Cyrillic or a dative-case affix (viz., I or U), which was neither alphabetically nor phonologically ambiguous.

Because in Serbo-Croatian, recognition latencies to a noun vary with inflected case in such a way that nominatives tend to be faster than datives (Lukatela, Gligorijević, Kostić, & Turvey, 1980; Kostić, 1991), the critical comparisons always held affix constant and focused on the difference between presenting forms of the base morpheme that were phonologically bivalent and presenting forms that were phonologically unequivocal. That is, ambiguous and unequivocal forms of the same base morpheme were compared. Results indicated a significant effect of (phonological ambiguous or unequivocal) base morpheme when the affix was phonologically ambiguous (viz., nominative) but not when it was phonologically unequivocal (viz., dative). Within the affix-stripping-decomposition account, differences among forms that share a base morpheme, but differ with respect to affix, may be accommodated by a check of affix-stem compatibility, which occurs after the base morpheme has been segmented and accessed in the lexicon. However, differences that reflect phonological characteristics of the base morpheme are not anticipated. Moreover, in that study, when affixes were phonologically ambiguous, the difference between the ambiguous and the

unequivocal forms of the base morpheme increased as the number of ambiguous letters in the base morpheme increased.

As is argued in that paper, the interaction of base morpheme ambiguity and affix can be interpreted within the decomposition before access framework if alphabet specification is retained after affixes are stripped. The effect of the number of ambiguous letters, which has been replicated in other experimental contexts (Feldman & Turvey, 1983; Lukatela, Feldman, Turvey, Carello, & Katz, 1989a; Lukatela, Turvey, Feldman, Carello, & Katz 1989b), is more problematic, however. The authors therefore interpreted these data as evidence that both the base morpheme and the affix (either together or separately) contribute to lexical access time.

The first study presented here builds on these results and extends them to a set of 24 verbs that possess a phonologically ambiguous base morpheme when written in one alphabet and a phonologically unequivocal analog when written in the other. Here, in contrast to the earlier work (Feldman et al., 1983), ambiguity of the base morpheme was equally distributed across alphabets. For example, the base morpheme of the verb meaning "call" is phonemically unique when transcribed in Roman JAV /jav/, but phonemically ambiguous when written in Cyrillic. (JAB can be pronounced as /jav/ which is meaningful or as /jab/ which is meaningless.) By contrast, the base morpheme of the verb meaning "melt" is phonemically unique when written in Cyrillic TOII, but phonemically ambiguous when written in Roman TOP (pronounced as /top/ or as /tor/). To the base morpheme was appended either an inflectional affix that was ambiguous with respect to alphabet (viz., E) or a verbal affix that included a letter that unequivocally specified alphabet in both its Roman and Cyrillic form (viz., IMO, I IMO). To summarize, verbal base morphemes were presented in their Roman and their Cyrillic transcriptions where one of those forms was phonologically ambiguous and one was phonologically unequivocal. Affixed to the base morpheme was (1) the inflectional affix for third person plural (i.e., E) which is alphabetically (but not phonologically) ambiguous because it is written the same way in Roman and in Cyrillic; (2) The first person plural affix which is written IMO in Roman and IIMO in Cyrillic; that is, it always includes a unique letter (viz., I or I) that necessarily specifies alphabet. Third and first person plural forms were selected because recognition latencies tend to be nearly equivalent in their unequivocal form (Kostić, 1991). Skilled readers who were undergraduates at the University of Belgrade and were fluent in both alphabets served as subjects in either a lexical decision or a naming task. To anticipate, a simple decomposition account can accommodate effects of phonological ambiguity to the base morpheme, but not an interaction of base morpheme and affix.

Latencies and errors with regard to ambiguous base morphemes and their unequivocal controls for ambiguous and unequivocal affixes are summarized in Table 1. Effects are reported when analyses of variance treating both subjects and items as random variables were significant. For decision latencies (for times between 1,400 ms and 400 ms), the effect of base morpheme ambiguity was sig-

Table 1. Decision latencies (and errors) to morphologically complex verb forms with phonologically ambiguous or unequivocal components.

Affix: Stem: Example:	Ambiguous		Unequivocal	
	Ambiguous	Unequivocal	Ambiguous	Unequivocal
	JABE	JAVE	JABI IMO	JAVIMO
Lexical decision:	729 (28)	671 (14.3)	677 (9.2)	664 (6.6)
Naming:	616 (25.9)	588 (12.5)	626 (17.6)	613 (11.8)

nificant, as was the interaction of affix by base morpheme. For decision errors, a significant effect of base morpheme and affix as well as an interaction of base and affix was observed.

The results of *t*-tests indicated that mean decision latencies for pairs such as JABE (729 ms) and JAVE (671 ms) that differ only with respect to ambiguity of the base morpheme, but retain the same affix, were significantly different $F(1,27) = 18.01$, $MS_e = 4873$, $p < .001$. Pairs such as JAVIMO (664 ms) and JABИМО (677) that differed with respect to ambiguity of base morpheme¹, but shared the same affix (in different alphabet forms) did not differ. Mean errors for pairs such as JABE (28) and JAVE (14.3) were also significantly different, $F(1,27) = 22.5$, $MS_e = 233$, $p < .001$. Finally, pairs such as JAVIMO (9.2) and JABИМО (6.6) that differed on ambiguity of base morpheme, but shared the same affix (in different alphabet forms), did not differ.

In the analysis of naming latencies (for times between 1,400 ms and 400 ms) only the effect of base morpheme ambiguity was significant. Naming errors, however, revealed a significant effect of base morpheme as well as an effect of affix and a marginally significant interaction of base and affix.

The results of *t*-tests indicated that mean naming latencies for pairs such as JABE (616 ms) and JAVE (588 ms) that differ only with respect to ambiguity of the base morpheme, but retain the same affix, were significantly different, $F(1,35) = 4.72$, $MS_e = 5652$, $p < .04$. Pairs such as JAVIMO (613 ms) and JABИМО (626 ms) that differed with respect to ambiguity of base morpheme, but shared the same affix (in different alphabet forms), did not differ significantly.

Mean errors in naming for pairs such as JABE (25.9) and JAVE (12.5) were significantly different, $F(1,35) = 45.08$, $MS_e = 144$, $p < .001$. Pairs such as JAVIMO (17.6) and JABИМО (11.8) also differed, $F(1,35) = 7.27$, $MS_e = 166$, $p < .01$. Pairs such as JAVE (12.5) and JAVIMO (11.8) did not.

If morphologically complex words were simply stripped of their affixes before lexical access, then assuming that phonological codes are computed prelexically in Serbo-Croatian, one might expect to observe ambiguity effects, regardless of the phonological characteristics of the affix. If the compatibility of the affix with the stem also

influenced latencies, then one might obtain affix effects as well. Instead, in the present experiment, characteristics of the stem (i.e., stem ambiguity) and of the affix (i.e., alphabet specificity) interacted. This outcome replicates the results of Feldman et al. (1983) which focused on a small set of inflected nouns and it extends those findings to a more extensive set of inflected verb forms, some of which were ambiguous in their Roman transcription and some of which were ambiguous in their Cyrillic transcription. It also includes both lexical decision and naming as dependent measures. In contrast to the original work, analyses of the number of ambiguous letters are not provided here. The general outcome is consistent with the claim that the base morpheme alone is not a sufficient unit for lexical access in Serbo-Croatian because alphabet information from the inflectional affix is preserved for lexical access. In conclusion, both morphological components must be analyzed in the course of word recognition.

Morphological effects in the lexicon

The second study in the series provides evidence that, at least under some conditions, morphological effects do arise in the lexicon. The experimental strategy entails a comparison of the lexical-decision and naming measures in order to insure that the facilitation due to morphological relatedness in a repetition-priming task does not reflect task-specific processes. When analogous effects arise in lexical decision and naming, they are interpreted as revealing lexical processes. Effects observed in lexical decision without naming are sometimes treated as post-lexical in origin (Balota & Chumbley, 1984; 1985). However, others have claimed that when pseudowords are structured like words and subjects are required to process materials with respect to lexical knowledge, even though effects tend to be somewhat attenuated in naming relative to lexical decision, both tasks reveal lexical effects (Paap, Mc Donald, Schvaneveldt, & Noel, 1987; see also Monsell, Doyle, & Haggard, 1989).

Significant facilitation among visually presented morphologically related words in the variant of the lexical decision task known as repetition priming (Stanners et al., 1979) is well documented and is generally interpreted as evidence that morphological relationships constitute a principle of organization within the internal lexicon. Typically, morphologically related primes reduce target decision latencies and error rates. Primes and targets can be unaffixed, inflected, or derived forms in either the same or

¹ These forms also differed with respect to number of unique letters but (in contrast to Lukatela et al., 1990) this distinction did not significantly affect decision latencies.

different modalities. Sometimes the reduction with morphological relatives as primes is equivalent to the effect of an identical repetition (Fowler et al., 1985). Effects of morphological relatedness persist in the lexical decision task across a variety of languages including Serbo-Croatian (Feldman & Fowler, 1987a) and Hebrew (Bentin & Feldman, 1991) as well as English (Fowler et al., 1985; Feldman, 1991) and American Sign Language (Hanson & Feldman, 1989). It is unclear from these studies, however, whether these morphological effects are specific to the lexical decision task and reflect strategic or other post-lexical factors. In the second study, identical materials were presented to different subjects for either lexical decision or rapid naming.

Facilitation produced by two types of morphologically related primes, inflections, and derivations were compared. In English, inflectional formations relative to derivational formations tend to be more similar in form and meaning to their base morpheme. Moreover, the number of inflectional affixes is severely limited in relation to the number of derivational affixes. These limitations impede a rigorous experimental comparison between types of formation with English materials. By contrast, in Serbo-Croatian it is possible to identify inflection-derivation pairs with only minimal differences in form and meaning. One such contrast entails inflected verb forms that differ in aspect.

Aspect reflects temporal properties of the verb which may vary with particular verbs, but generally include inceptive variants of stative verbs and iterative variants of verbs that describe discrete events (Bybee, 1985). It is relevant to note that the morphological status of aspectual formations is not universal across languages (compare Anderson, 1982, with Bybee, 1985). In the present study, it is assumed that aspect is a derivational formation for the class of verbs included because it was always the case that two distinct verbal entries existed in the dictionary. Each entry was formed around the same base morpheme, but differed with respect to the set of inflectional affixes it required. If morphological relatedness by inflection and derivation are differently represented in the lexicon, then with controls for orthographic overlap, the magnitude of facilitation when forms that are inflectionally related to the target are presented as primes should be enhanced in relation to the pattern with derivationally related primes.

Twenty-seven word triples in Serbo-Croatian were selected. Each consisted of a target verb, an inflectionally related prime, and a derivationally related prime. Targets consisted of present-tense verb forms in the first or third person plural. Inflected forms were first person singular of those same verbs. Derived forms were first person singular of different verbs formed from the same base morpheme, but differed in the temporal qualities of the action they conveyed.

Typically, the target and inflected prime were perfective forms and the derived prime was imperfective. Semantically, this distinction is relatively minor, entailing contrasts between completed and durative actions such as HE SAT DOWN and HE WAS SITTING. Structurally, all members of a triple were composed of the same base morpheme, but differed with respect to (the vowel of) the inflectional affix. For example, perfective forms of the base morpheme NOS

meaning "carry" are formed around the vowel I such as NOSIM, NOSIŠ, NOSI. . . NOSE whereas imperfective forms are formed around A such as NOSAM, NOSAŠ, NOSA. . . NOSAJU. The orthographic and phonemic overlap of primes and their morphologically related targets was matched by selecting third person plural forms ending in E as targets and necessarily as identity primes (e.g., NOSE), forms ending in IM (e.g., NOSIM) as inflectionally related primes and verbs differing in aspect (e.g., NOSAM) as the derivationally related primes. Inflectional and derivational primes were always presented in the same person and number. Pseudoword triples were created by substituting vowels or consonants within base morphemes in order to create meaningless bases that were orthographically legal. To these, real inflected affixes were appended in order to create sets of pseudowords that differed only with respect to affix. Like words, pseudoword targets were preceded by identity, inflected and derivationally related primes and inflected and derived forms differed only by the vowel in the verbal affix.

Three test orders were created. Each contained 114 items and included equal numbers of word and pseudoword targets preceded an average of 10 items earlier in the list by a morphologically related prime. In each test order, all three types of prime were equally represented. Across the three test orders, each word or pseudoword was preceded by all three types of morphologically related prime. The same test orders were presented to 27 subjects for a lexical decision judgement and to a different set of 27 subjects for a naming response. The presentation procedure was identical in both tasks and entailed the presentation of isolated words and pseudowords for 750 ms with an inter-trial interval of 2,000 ms.

Mean lexical decision and naming latencies for the second experiment are summarized in Table 2. An analysis of lexical decision latencies (within 2 *SD* from the mean) and errors for words revealed a significant effect of type of prime. Facilitation with inflectional primes was greater than with derivational primes, $F(1,26) = 8.11$, $MS_e = 1264$, $p < .008$. Neither pseudoword decision latencies nor errors revealed an effect of prime.

In word naming, latencies replicated the effect of type of prime. The differential effect of inflectional and derivational primes missed significance, $F(1,26) = 2.83$,

Table 2. Facilitation in repetition priming with no prime, identity, inflections and derivations as primes.

	Type of prime			
	No prime	Identity	Inflectional	Derivational
		NOSE	NOSIM	NOSAM
NOSE		NOSE	NOSE	prime target
Lexical decision:				
648	578	569	596	
9.5	6.4	6.4	9.3	
Naming:				
597	569	567	582	
10.3	9.5	7.4	11.52	

Table 3. Examples of morphologically simple and complex words.

Prefix	Base	Suffix:		Meaning
		Derivation	Inflection	
English:				
RE	DRUM	(M) ER		
	SOFT	EN		
	WRITE		S	
	WRITE			
	WIN		(N)ING	
	BIT		(T)EN	
	SUMMER			
	OFTEN			
	WHITING			
	INNING			
MITTEN				
Serbo-Croatian:				
DO S	SLAV		OM	celebration
	ČEK			reception
	PUST			descent
	CEV		I	pipes
	CED		I	he wrings
	KIŠ	ICA		drizzle
	TON		EM	I dive
	SLALOM			ski term
	DOBOŠ			drum
	MIŠICA			muscle
	FONEM			phoneme
	NOS		IM	I carry (per)
	NOS		AM	I carry (imper)

$MS_e = 10046$, $p < .10$ as did the difference between no prime and derivational prime conditions. By contrast, the effect of inflectional primes was significantly greater than the effect of no prime, $F(1,26) = 12.09$, $MS_e = 1002$, $p < .002$. Finally, pseudoword naming latencies revealed a significant effect of type of prime that reflected differences between the no prime condition and each of the other conditions. The accuracy measure did not show the same pattern, however.

Comparisons of the magnitude of facilitation for targets preceded by inflectionally and derivationally related primes revealed significantly enhanced facilitation with inflections relative to derivations in lexical decision and a similar, but dramatically attenuated, pattern in naming. That the magnitude of priming in lexical decision is sensitive to the type of morphological relation when formal properties of the affixes are controlled is important. It provides psychological support for a linguistic distinction and suggests that the failure to observe a similar effect in English may reflect differences in form between inflectional and derivational affixes. In naming, inflectionally related primes produced significant facilitation, but the interpretation of derivational primes poses a problem. On one hand, they make targets no faster or more accurate than in the No Prime condition, but on the other, they are not statistically slower than inflectional primes. Failure to obtain significant effects of type of prime may reflect generally diminished morphological facilitation in naming relative to lexical decision. An analogous effect of task has

been observed under conditions of semantic facilitation (Katz & Feldman, 1983; Frost, Katz, & Bentin, 1987).

In summary, inflections do produce a systematic pattern of facilitation across tasks. This relation is represented in the lexicon and cannot easily be reduced to one of semantic activation. What remains unresolved is whether the relation among forms that share a base morpheme, but differ with respect to derivational affixes, is also represented in the lexicon. The results obtained with lexical decision suggest that they are. The results obtained in naming are equivocal in that the answer hinges on the interpretation of a weak pattern of facilitation. Because the pattern of means over task are very similar in that latencies to targets following derivations fall between latencies with no prime and those with inflectional primes, and because inflectional relations are represented in the lexicon, it seems likely that the lexical status of inflections and derivations do differ. It is not obvious whether these data are better captured by a morphological principle of organization that differentiates inflections from derivations in terms of linkages among lexical entries or by decomposed lexical entries where inflectionally related forms are more tightly clustered than are derivationally related forms. What is certain is that facilitation among morphologically related lexical entries cannot be reduced to patterns of semantic and orthographic activation.

Morphological segmentation

The final study in this report provides evidence that the morphological constituents of a word are sometimes available to a processing mechanism. The experimental manipulation exploits the fact that the morphemic structure of many words is not wholly transparent because the same sequence of letters can function morphemically in one context and nonmorphemically in another. For example, the final ER sequence in DRUMMER is morphemic, whereas SUMMER contains only one morpheme. Similarly, the UN in UNTIE is morphemic, whereas UNCLE is morphologically simple. Examples of morphologically complex and simple words are presented in Table 3.

Inspired by the pattern of errors in spontaneous speech, a new experimental technique was devised to obtain evidence for morphological constituents (Feldman & Fowler, 1987b). In the *segment shifting task*, subjects are instructed to segment and shift a designated segment from a source word onto a target word and to name the new result aloud as rapidly as possible. In all cases, the product is a morphologically complex and real word. On some occasions, the affixed element (e. g., ER) is morphemic in status. At other times it is not. Morphemic and nonmorphemic endings are controlled for phonemic and syllabic structure (Tyler & Nagy, 1989). For example, subjects viewed source words such as SUMMER or DRUMMER for 500 ms, then the ER was underlined, the target word PAINT appeared, and a clock started. In each case, subjects said PAINTER, and onset to vocalization was measured. The segment shifting procedure is depicted in Figure 1.

In the first segment shifting experiment, 30 American college students were presented with 40 pairs of English

materials, including both inflectional and derivational morphemic affixes or their nonmorphological controls. For example, experimental materials consisted of inflected words such as WINNING and its phonemically controlled nonmorphological pair INNING and derived words such as SOFTEN and its phonemically controlled nonmorphological pair OFTEN. Each subject saw only one member of a pair. The outcome was significantly faster (15 ms) naming latencies to the target derived from a source word with a morphemic ending than from one with a nonmorphemic ending. Because of the severe constraints on creating materials in the inflectionally impoverished language of English (all three inflectional affixes and six derivational affixes with no phonological influence on the base were included), no comparison between types of morphological formation was possible. Subsequent experiments in this series were conducted in Serbo-Croatian and explicit comparisons between types of morphological formation were performed.

The morphological effect in segment shifting was replicated with 26 students at the University of Belgrade and 16 pairs of Serbo-Croatian materials. Morphemic segments consisted of masculine-singular instrumentals, such as SLAVOM, and nonmorphemic controls consisting of segments ending with the same sequence of letters without a morphemic function, such as SLALOM. Morphemic segments were shifted (22 ms) significantly faster than their nonmorphemic controls. (Error rates were very low and produced no significant results.) Another condition of the experiment included homographic morphemes. Materials consisted of morphologically complex source words with morphological affixes that were compatible with the target word (same syntactic category and gender) and morphologically complex source words that were not. That is, the Serbo-Croatian analog of nominal or verbal S was shifted to another word of the same (consistent) or a different (inconsistent) word class. For example, the I from CEVI meaning "pipes" in the nominative plural or CEDI meaning "he wrings" was shifted to the target word RAD in order to form the word RADI meaning "he works". Note that in both source words the I is morphemic. What differs is the consistency or the inconsistency of the syntactic category of the source word and the target word. In this condition, no significant effects of consistency (-6 ms) were observed. Shifting rates for I segments derived from verbal and nominal source words were equivalent.

In principle, the locus of the observed effect could be the process of either segmenting components from the source or affixing them to the target. Because there were no source-target compatibility effects, this outcome suggests the segmentation interpretation. Accordingly, morphemic affixes are more easily segmented from a source word than are nonmorphemic controls. Because morphemic and nonmorphemic affixes were controlled for phonemic structure, one interpretation of this outcome is that it reflects greater coherence of the morphemic letter sequences compared with the nonmorphemic sequences.

The linguistic productivity and lexical structure of inflectional, but not derivational, formations noted above, leads one to expect inflectional affixes to show enhanced segmentation effects in relation to derivational affixes. The third experiment in this series investigated the effect of

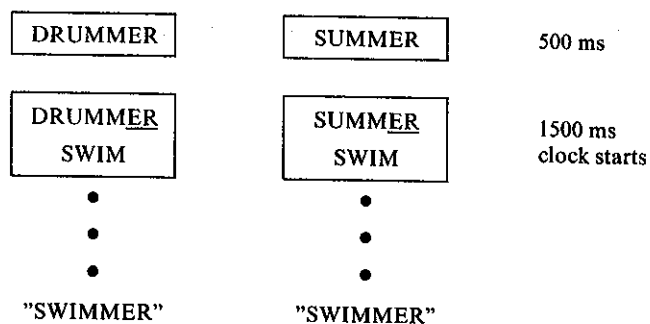


Fig. 1. The segment shifting procedure.

type of morphological formation on segment shifting. In this experiment, subjects had to substitute the affix from the source word for the affix on the target word and name the result aloud. Materials consisted of 24 Serbo-Croatian word pairs and the critical contrast compared the shifting latency of inflectional and derivational morphemic affixes with that of their nonmorphemic controls. Inflectional segments consisting of first person singular verbs ending in IM such as LEŽIM meaning "I recline" and their nonmorphemic controls such as REŽIM meaning "regime" were shifted to inflected targets such as BACE meaning "they throw" and subjects responded BACIM meaning "I throw". Likewise, derivational segments consisting of singular diminutives ending in ICA (and AK) such as BAŠTICA meaning "little garden" and their controls such as KOŠTICA meaning "seed" were shifted to target, such as BUBA meaning "bug" and subjects responded BUBICA meaning "little bug". In this experiment, the task required the subject to drop the original (morphemic) affix on the target (e.g., A) and to substitute the affix from the source word (e.g., ICA). Differences here are interesting insofar as they reveal processing contrasts between inflections and derivations that are controlled for phonemic structure and stress. It is important to note that this contrast of morphological types could not be performed in English, owing to the paucity of inflectional affixes and the stress-pattern differences between inflections and many derivations.

Results in Serbo-Croatian revealed a significant morphological effect in segment-shifting latencies for inflectional pairs (57 ms), but not for derivational pairs (-11 ms). No effects approached significance with the error measure. They are consistent with the linguistic distinction between morphological types noted above and with the pattern of speech whereby inflections enter into speech errors more frequently than do derivations (Garrett, 1980). This finding suggests that the constituent structure of inflectional formations is more readily available to a processing mechanism than that of derivation.

Conclusion

It is evident from the data described above that the morphological components of a morphologically complex word can be accessed in the course of recognizing that word. Over a variety of experimental tasks, evidence of morpho-

logical analysis was observed. This process could not be reduced to one of identifying the stem within a complex form and using it as the unit by which representations in the lexicon were accessed, however, because phonological characteristics of the stem, as well as the affix, influenced recognition latencies under some conditions. Specifically, among Serbo-Croatian readers, phonological bivalence of a stem slowed decision and naming performance when the inflectional affix was ambiguous with respect to alphabet, but not when it uniquely specified alphabet. If the stem in isolation provided the unit for lexical access, then characteristics of the stem should influence all (or no) inflectionally related forms. Effects of affix as well as stem are consistent with the conclusion of Katz and his colleagues (Katz, Rexer, & Lukatela, 1991) that decomposition of morphologically complex forms does not occur prior to accessing the lexicon.

The pattern of facilitation among morphologically related, but not among orthographically similar, forms in repetition priming (Feldman & Moskovljević, 1987) in conjunction with the results of Experiment 2, provide compelling evidence that morphological relations are appreciated in the lexicon and that inflectional and derivational processing may differ even when semantic and orthographic similarity between these two types of formations is controlled. In both lexical decision and naming, inflectionally related primes produced significant target facilitation at lags of 10 intervening items. Facilitation by derivationally related primes in naming was weak compared with inflectional primes, however, and this outcome warrants further investigation. Without positing stems as the unit of lexical access, it appears that the presence of a common morphological component embedded in pairs of morphologically complex words can dramatically facilitate processing, even when relatives are presented with lags of several items. Because the patterns emerge when the sound and the spelling of the base morpheme are altered across prime and target, as well as when they are preserved, this outcome has been interpreted by this author as reflecting a morphological principle of organization among whole-word forms.

Results of the segment shifting task provide the most compelling evidence for morphological constituents in word recognition. When lexical and phonological output is controlled by experimental design, morphological segments are manipulated more efficiently than nonmorphological controls over a variety of morphological environments. Moreover, effects are more systematic for inflections than for derivations. This outcome suggests that inflectional affixes are more easily segmented from the base than are derivational affixes and it is consistent with the linguists' claim that the internal structure of inflections is more accessible than that of derivations.

In summary, there is strong support from a variety of experimental paradigms for the psychological processing of the morpheme. The results in classical lexical decision and naming tasks do not differentiate convincingly between a morphological principle of organization in the lexicon and lexical representations that are decomposed into their morphological constituents, however. In a task that includes the manipulation of the inflectional affixes of

a word and therefore resembles the task of inserting lexical entries into a syntactic frame of a sentence (Garrett, 1980; 1982), performance is constrained by the morphological status of the shifted component. Analogous effects with derivations are very weak or absent, however, and this outcome supports a lexical distinction between inflection and derivation.

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