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Morphological Facilitation Following Prefixed but Not Suffixed Primes: Lexical Architecture or Modality-Specific Processes?

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Morphological facilitation was examined in immediate (Experiment 1) and long-term (Experiment 2) lexical decision with English materials. For the target (*payment*), related primes consisted of base-alone (*pay*), affix-plus-base (*prepay*), or base-plus-affix (*payable*) combinations, thereby defining position of overlap. In addition, modality of presentation varied for primes and targets (Experiment 1). At short lags, the advantage for *prepay–payment* over *payable–payment* type pairs was significant when primes were visual (V) and targets were auditory (A), marginal under AV conditions, and nonexistent under VV conditions. At long lags, the magnitude of VV did not vary with position of overlap. Morphological facilitation was stable across changes in modality following prefixed and simple forms, reflecting lexical architecture. By contrast, the absence of facilitation following suffixed primes presented cross-modally implicates modality-specific processing.

In English, morphologically complex words can be formed by adding either a prefix or a suffix, both a prefix and a suffix, or two or more suffixes to a base morpheme. In variants of the lexical decision task, discrepant outcomes for affix-plus-base (viz., prefixed) and base-plus-affix (viz., suffixed) combinations suggest that either the units with which one accesses the lexicon (e.g., Taft & Forster, 1975) or the lexical representations themselves (e.g., Caramazza, Laudanna, & Romani, 1988) are decomposed into morphological constituents. One account of morphological processing, based predominantly on results using the cross-modal priming technique, emphasizes a modality-neutral lexical architecture (Marslen-Wilson, Tyler, Waksler, & Older, 1994). An alternative interpretation would also accommodate modality-specific aspects of processing. In the present study, we manipulated the positioning of affixes relative to the shared base morpheme. We compared morphological facilitation following prefixed and suffixed primes across a variety of modality configurations of prime and target to evaluate the claim that cross-modal priming taps into modality-neutral representations within the lexicon. Similar patterns of facilitation following prefixed forms and suffixed forms across manipulations of presentation modality of prime and of target would be consistent with a lexical locus. By implication, differing patterns across varying modality configurations of prime and target would implicate modality-specific processes for which the locus may, but need not, be lexical.

To motivate this study, we reviewed the experimental literature on the recognition of prefixed and suffixed forms as well as some possible accounts of purported differences. The original studies examined prefixed and suffixed forms presented in isolation, that is, without a prime context. More recent studies have examined the effects of prefixed or suffixed derived primes on recognition of a morphologically related target at short lags within and across presentation modalities as well as at long lags when presentations are visual. The primary evidence for differences as a function of affix position derives from the cross-modal priming task, a task that allegedly accesses modality-neural lexical representations. Accordingly, it is the point of departure for our empirical research.

Morphological Processing: Prefixed and Suffixed Forms

One line of investigation contrasting prefixed and suffixed forms examines factors that differentially influence recognition of truly affixed and pseudoaffixed forms presented in isolation. For example, lexical decision latencies for pseudoprefixed words (e.g., *religion*) tend to be slower than for prefixed (e.g., *regard*) or control words (Bergman, Hudson, & Eling, 1988; Taft, 1981; Taft & Forster, 1975), whereas differences between true and pseudosuffixed words are not reliable. Pseudoagentive suffixes (e.g., *poeder* meaning *powder*) in Dutch (Bergman et al., 1988) and a variety of derived endings in English (Henderson, Wallis, & Knight, 1984; Manelis & Tharp, 1977; Taft, 1976, as cited in Taft, 1988) all fail to reveal effects of pseudosuffixation. In addition, cumulative (base) frequency effects for suffixed, but not for prefixed, words in French suggest that only suffixed words can be accessed from the base morpheme (Beauvillain, 1996; Colé, Beauvillain, & Segui, 1989; Meunier & Segui, 1999b). Studies typically tend to report a significant effect for one position of affixation and a null effect for the other. Direct comparisons between prefixed and suffixed forms are infrequent.

The pattern of facilitation among morphologically related forms in the primed lexical decision task also provides evidence that morphological structure influences word recognition. At both short and long lags, decision latencies to visual targets are generally facilitated by the prior presentation of another word formed from the same base morpheme (or root morpheme, in Hebrew). Short-term morphological facilitation arises when relatives are presented

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visually, in immediate succession, at prime durations ranging from 32 ms to 300 ms (Feldman, 2000; Feldman & Soltano, 1999). It is also present across varying modality configurations (e.g., auditory prime and visual target as well as auditory prime and auditory target) of prime and target at short lags (Allen & Badecker, 1999; Fowler, Napps, & Feldman, 1985; see also Emmorey, 1989; Kirsner, Milech, & Standen, 1983; Marslen-Wilson, Zhou, & Ford, 1996). Moreover, the magnitude of morphological facilitation is sensitive to the degree of overlapping form when relatives are visually presented without a mask in immediate succession (Feldman, 1999). For example, the magnitude of facilitation measured relative to an unrelated baseline is greatest following *turned–turn* type pairs, intermediate following *bought–buy* type pairs, and most reduced following *fell–fall* type pairs. The finding that the magnitude of morphological facilitation among inflectional relatives is sensitive to the degree of overlap may be difficult to reconcile with an account of morphological facilitation based on activation of decomposed lexical entries, however.

Morphological facilitation also arises when 10 or more items intervene between related forms. Long-term morphological facilitation has been replicated across a variety of languages with differing structures, including Serbian[1] (Feldman, 1994) and English (Feldman, 1992; Fowler et al., 1985; Stanners, Neiser, Hernon, & Hall, 1979) as well as Hebrew (Bentin & Feldman, 1990; Feldman & Bentin, 1994) and American Sign Language (Hanson & Feldman, 1989). It is interesting that long-term facilitation is not particularly sensitive to alterations in form. Comparable facilitation has been demonstrated for "irregular" morphological formations that undergo sound and spelling change (Feldman & Fowler, 1987) and for "regular" forms that do not (Fowler et al., 1985; Stolz & Feldman, 1995). In a similar manner, long-term morphological facilitation for Hebrew word forms does not differ depending on whether an infixed morpheme (viz., word pattern) disrupts the letter sequence that forms the root (Feldman & Bentin, 1994).

Although effects of form are evident among morphological relatives in the short-term priming task, it is well documented that morphological facilitation cannot be attributed to similarity of form alone. Morphologically related primes produce reliable facilitation, but effects of orthographically similar and morphologically unrelated primes vary in direction as well as magnitude. Primes that are orthographically similar but morphologically unrelated (e.g., *vowel*) have no effect on target (e.g., *vow*) decision latencies when primes and targets are separated by many intervening items (Drews & Zwitserlood, 1995; Feldman & Moskovljević, 1987; Stolz & Feldman, 1995). In short-term priming, *vowel–vow* type pairs tend to produce facilitation at very short stimulus onset asynchronies (SOAs) that is smaller in magnitude than morphological facilitation (Feldman, 2000). By contrast, at SOAs on the order of 300 ms, *vowel–vow* type pairs produce significant inhibition (Drews & Zwitserlood, 1995; Feldman, 2000).

Morphological relatives do not always facilitate each other, and this observation is striking given the generalizability of morphological facilitation. The exceptional morphological contexts that have been identified are limited, however. One failure to observe morphological facilitation involves repetition of affixes (as contrasted with base morphemes) in the forward-masking procedure (Giraudo & Grainger, 2000). In particular, primes and targets that shared a prefix produced facilitation, whereas pairs that shared a suffix did not. A second failure is that irregular verb forms that cannot be decomposed into base morpheme plus affix fail to produce facilitation in an auditory prime–visual target cross-modal short-term priming task. Regular forms (e.g., *walk+ed–walk*) show strong facilitation (Marslen-Wilson, 1989), whereas orthographically similar irregular morphological relatives (e.g., *gave–give*) show no facilitation (Allen & Badecker, 1999). In addition, words similar in form (e.g., *slim–slam*) produce inhibition, but dissimilar morphological relatives (e.g., *taught–teach*) produce facilitation. The overall pattern suggests that the failure to observe morphological facilitation for *gave–give* type pairs presented cross-modally may be tied to the characteristics of overlap among forms (Allen & Badecker, 1999).

Finally, under cross-modal presentations (Marslen-Wilson et al., 1994), responses to targets that followed a morphologically related suffixed prime were no faster than responses following an unrelated prime. Specifically, decision latencies for a suffixed target (e.g., *payment*) differed depending on whether its prime included a prefix (e.g., *pre* in *prepay*) or a suffix (e.g., *able* in *payable*) in addition to the shared base morpheme (e.g., *pay*). Targets that followed a prefixed prime (e.g., *prepay–payment*) showed shorter decision latencies than targets that followed a suffixed prime (e.g., *payable–payment*). Cross-modal morphological facilitation is evidently constrained by position of overlapping constituents.

In the original study by Marslen-Wilson et al. (1994), primes were presented auditorily and targets visually, because the cross-modal presentation technique allegedly taps into lexical, as contrasted with modality-specific, access representations. Moreover, the authors assumed that lexical representations of morphologically complex forms are decomposed into base and affix components. Accordingly, they interpreted the failure to observe morphological facilitation among word pairs that shared a base morpheme (morphologically related) but differed with respect to a suffix as evidence of inhibitory connections between the suffixes that are appropriate for a particular base morpheme within the lexical (viz., suffix–suffix interference). In essence, the absence of facilitation for *payable–payment* type pairs was purported to reflect the convergence of prime and target onto the same modality-neutral lexical unit (viz., *pay*) together with competition between the potential suffixes (e.g., *able, ment*) for that unit (Marslen-Wilson, Zhou et al., 1996). No inhibitory connections existed between prefixes, however. Inhibition was restricted to words that resembled each other initially and therefore belonged to the same cohort. Because targets following prefixed and suffixed relatives were different words, they could not be contrasted directly, however.[2]

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[1] At the time of publication, we referred to the same language as Serbo-Croatian.

[2] When morphologically complex words are presented in isolation, several properties of the base morpheme that influence recognition have been identified. For example, the cumulative frequency of a base morpheme can affect positive decision latencies as can the surface frequency of the particular word in which it appears. Similar effects have been demonstrated in Italian (Burani, Salmaso, & Caramazza, 1984), French (Colé et al., 1989), and English for both regular (Katz, Rexer, & Lukatela, 1991; Taft, 1979) and irregular forms (Kelliher & Henderson, 1990). A related property of base morphemes is family size, defined as the number of derived and compound words formed from a base morpheme. With controls for cumulative frequency, indices of family size influence recognition in a variety of tasks in Dutch (Schreuder & Baayen, 1997), Hebrew (Feldman, Frost, & Pnini, 1995), and French (Meunier & Segui, 1999a, 1999b).

In a subsequent study, the failure to observe either facilitation or inhibition between two suffixed forms that shared a base morpheme occurred when both prime and target were presented auditorily (Marslen-Wilson, Zhou et al., 1996). To our knowledge, however, no one has examined whether visual primes followed by auditory targets also fail to produce morphological facilitation. This oversight is curious because a stable pattern over manipulations of prime and target modality is essential to verify the claim that cross-modal priming reflects a modality-neutral lexical architecture as contrasted with modality-specific processing.

Alternatives to Decomposition: Prefixed and Suffixed Forms

There are several possible explanations as to why the recognition processes for prefixed forms and suffixed forms may not be identical, only some of which require an interpretation based on decomposed representations of morphologically complex forms. Differences between forms could reflect the way in which morphologically complex forms are represented or accessed in the lexicon. For example, effects of pseudoaffixation for prefixed but not for suffixed forms presented in isolation, as well as cumulative frequency effects for suffixed but not for prefixed forms, are compatible with a general class of left-to-right models of visual processing in which a word initial substring has a greater influence on processing than a word final substring (Hudson, 1990; Hudson & Buijs, 1995; Libben, 1994; Taft & Forster, 1975).[3] Left-to-right models of processing can, but need not, stipulate that lexical entries are morphologically decomposed. Models of auditory word processing necessarily posit early-to-late processing but vary as to whether the critical units are full word forms (e.g., Marslen-Wilson, 1989) or constituents, either morphemes (e.g., Schriefers, Zwitserlood, & Roelofs, 1991; Wurm, 1998) or strong syllables (e.g., Cutler & Norris, 1988).

An alternative account of processing differences between prefixed and suffixed forms emphasizes contrasting distributional properties of prefixes and suffixes (Frauenfelder & Schreuder, 1992; Laudanna & Burani, 1995). For example, in English, the affixation of a derivational suffix tends to change the word class of the base morpheme and to have semantic consequences that are not always predictable (see, e.g., Henderson, 1985). By contrast, prefixation tends not to change the word class of the base and tends to produce a relatively constrained set of alterations to the meaning of the base (Cutler, Hawkins, & Gulligan, 1985). Consequently, the semantic or perhaps syntactic effects of affixing to the base morpheme a prefix as contrasted with a suffix may not be equivalent. In essence, properties of particular morphemes such as affix productivity or semantic transparency may be responsible for the differences between prefixed and suffixed forms observed in recognition tasks (Wurm, 1998).

Finally, differences between prefixed and suffixed forms in word recognition tasks may reflect modality-specific aspects of processing that are not associated specifically with morphological constituents. In particular, suffixes may be especially problematic when either prime or target is presented auditorily, simply because they occur at the end of a word that is arrayed in time or because suffixation frequently involves greater phonological change to the base (and subsequent mismatch with the full word form) than does prefixation. Under auditory presentation conditions, similarity at the beginnings and ends of morphologically simple words does not influence word recognition in the same way (e.g., Radeau, Morais, & Segui, 1995). Rhyming primes (French analogs of *dart–cart*) tend to speed decision latencies, whereas overlap of the first three phonemes slows decision latencies (Radeau et al., 1995; see also Hamburger & Slowiaczek, 1996). It is plausible that a similar mechanism, linked to location of mismatching form, underlies the difference in recognition latencies between prefixed and suffixed word forms.

In summary, there are a variety of reasons why the recognition of prefixed forms and suffixed forms may differ, only some of which presume decomposed lexical entries. Of course, a comparison of morphological facilitation following prefixed and suffixed primes is informative, irrespective of the decomposition issue. In this study, we manipulated the positioning of affixes relative to the shared base morpheme and examined patterns of facilitation in the lexical decision task across a variety of modality configurations for prime and target. First, we replicated the finding by Marslen-Wilson et al. (1994) that decision latencies to morphologically complex (viz., suffixed) targets differ following affix-plus-base and base-plus-affix prime combinations. Then we interchanged the modality of presentation for prime and target to ask whether suffix inhibition requires an auditory presentation of the prime (Marslen-Wilson et al., 1994). Auditory presentations of the prime and visual presentations of the target are posited to converge onto the same modality-neutral lexical unit (e.g., Marslen-Wilson et al., 1994). Accordingly, differing patterns of facilitation (or inhibition) across various modality configurations of prime and target would constitute a challenge to the adequacy of an account of morphological processing based purely on a modality-neutral lexical architecture.

Finally, we examined the pattern of facilitation for visual targets preceded by visual primes so as to make a comparison with the cross-modal configurations. When both prime and target are presented visually, facilitation could be contaminated by the influence of access units or some other effect tied simply to similarity of orthographic form (Marslen-Wilson et al., 1994). However, a failure to obtain different outcomes under auditory–visual (AV) and visual–visual (VV) presentation conditions would undermine this concern. It is also the case that form-based effects are gener-

Finally, degree of semantic transparency of the base morpheme can be critical (Feldman & Soltano, 1999; Libben, Gibson, Yoon, & Sandra, 1997; Smith & Sterling, 1982; Wurm, 1998) and can even determine whether morphologically related forms produce facilitation or inhibition (Feldman & Soltano, 1999). One implication of identifying multiple dimensions of relevance to morphological processing is that when target words are not repeated across experimental conditions, valid comparisons necessitate elaborate matching.

[3] According to the affix stripping account, morphological affixes are stripped from stems prior to lexical access, and letter sequences that have the form but not the function of an affix introduce an additional stage of processing (Taft & Forster, 1975). In more current conceptualizations (Taft, 1994), however, the prefix stripping procedure is part of the access process, not a discrete stage prior to access, and the influence of the prefix on recognition is linked to general properties of the prefix and not necessarily to its status in a particular word. Properties of the affix that are plausible candidates include indices of productivity (Burani, 1993; Frauenfelder & Schreuder, 1992) and affix salience (Laudanna & Burani, 1995) or productivity (Wurm, 1998).

ally transient. Therefore, a secondary strategy of investigation was to compare facilitation in short-term priming (Experiment 1C) and when many items intervene (Experiment 2) between visually presented prime and target.

In all experiments, critical primes were formed from the same base morpheme as the target, and, over participants, the same target followed all types of primes, thereby controlling effects due to properties of the base morpheme. A distinct advantage of this design is that we could contrast target latencies following prefixed and suffixed forms directly across manipulations of presentation modality for prime and target.

Experiments 1A–C

In Experiment 1, we compared the magnitude of facilitation for complex targets (e.g., *payment*) immediately preceded by morphologically related primes that included a prefix (e.g., *prepay*) or a suffix (*payable*) that was different from that of the target. A base-alone prime (e.g., *pay*) and an unrelated prime (e.g., *usable*) were also included for each target. Experiment 1 included a chance to replicate *prepay–payment* facilitation and the absence of a *payable–payment* effect when the target was repeated across prime type. These are the findings on which Marslen-Wilson et al. (1994) based their claim of inhibitory lexical links between the morphological suffixes (but not prefixes) for a particular base morpheme. Following the design of Marslen-Wilson et al. (1994), we added fillers so that in Experiments 1A–C, only 30% of the primes that preceded word targets shared a base morpheme with the target. In Experiment 1A, primes were auditory, and targets were visual. Decision latencies and other measures of word recognition are generally at least as sensitive to properties of the target as they are to those of the prime. Therefore, it is perhaps surprising that the modality of the prime is purported to govern suffix–suffix interference (Marslen-Wilson, Zhou, et al., 1996). Accordingly, in Experiment 1B, we compared patterns of facilitation following prefixed and suffixed primes when primes were visual and targets were auditory. In Experiment 1C, both primes and targets were visual.

Effects that are truly lexical should generalize across manipulations in the modality of presentation for prime and target words. Systematic patterns of facilitation following simple and prefixed primes across varying modality configurations of prime and target would be consistent with a lexical account. Conversely, for suffixed targets that follow suffixed primes, changes in the pattern of inhibition and facilitation with manipulations of modality would provide a challenge to a lexical locus for the interference that arises between suffix forms that are morphologically related. In addition, a comparison of target latencies following suffixed and simple primes would be revealing about how the suffix is processed. In the terminology of suffix–suffix interference, the difference in latencies following suffixed and simple primes would provide an estimate of the magnitude of inhibition due to the presence of a suffix on the prime that differs from that of the target.

Method

Participants. Sixty students participated in Experiment 1A, 80 students participated in Experiment 1B, and 42 students participated in Experiment 1C. All were enrolled in an introductory psychology course at the University at Albany, State University of New York and participated in partial fulfillment of course requirements. All were native speakers of English.

Materials. Twenty-four sets of English materials were constructed. See the Appendix. Each set included a morphologically complex (viz., suffixed) word target (*payment*), three types of morphologically related primes, and one unrelated prime. The prefixed prime (*prepay*) was composed of a prefix and the base of the target. The suffixed prime was composed of a derivational suffix different from that of the target and the base of the target (*payable*). The simple prime (*pay*) consisted of the base form from which the target was derived. Prefixed and suffixed forms were selected so that changes to the meaning[4] and phonology of the stem were minimal and, across items, the length of the affix in letters was matched. Properties of the primes are summarized in Table 1. Prefixed and suffixed primes were matched for letter overlap with the target (69% and 68%, respectively), phoneme overlap with the target (64% and 63%, respectively), and affix length in letters (2.3 and 2.5, respectively) and phonemes (2.1 and 2.2, respectively). None of these comparisons even approached significance. The average surface frequency was 8.2 (SD = 12.3) for prefixed primes, 10.1 (SD = 12.2) for suffixed primes, and 99.8 (SD = 73.3) for simple primes. Each complex prime had a lower frequency than that of its target (M = 59.9, SD = 76.1). Unrelated primes included either a prefix or a suffix along with a base morpheme different from that of the target (*usable*).

Pseudoword targets were used as fillers and were constructed from pseudo-prefixed and pseudosuffixed words so as to resemble the word items in terms of affixation. Each consisted of an illegal combination of (potential) base morpheme and affix. Pseudoword targets were preceded by word primes so that lexicality of the prime did not provide a cue as to lexicality of the target. The simple prime condition consisted of a word (e.g., *govern*) followed by a pseudoword composed of an illegal combination of morphemes (e.g., *governly*).[5] Prefixed primes consisted of a prefixed or pseudoprefixed word (e.g., *intellect*) followed by the pseudobase with a suffix (e.g., *tellectly*). Suffixed primes were constructed from a suffixed or pseudosuffixed word (e.g., *murder*) and consisted of the pseudobase with a suffix (e.g., *murdence*). Unrelated primes consisted of a prefixed or suffixed word (e.g., *bigamist*) followed by an unrelated pseudobase with a suffix (e.g., *semblize*).

Design. Four test orders each containing 20 critical auditory prime and visual target pairs were created for Experiments 1A–C. Four items from the original set were inadvertently omitted (at random) when the test orders were constructed. To reduce the relatedness proportion to 30%, an additional 30 filler word–word pairs were created that were unrelated in form as well as meaning. As we described above, 20 of the 50 filler word–nonword trials were similar in structure to the word targets, and the remaining 30 were unrelated. Each test order included five tokens of each of the four types of word primes (viz., unrelated, simple, prefixed, and suffixed), and, across test orders, each word target followed all four types of prime. Consistent with the design used by Marslen-Wilson et al. (1994) different pseudoword targets followed each type of prime, and all primes

[4] Marslen-Wilson et al. (1994), in their study, matched prefixed primes and suffixed primes on their semantic relatedness to the target. Although, in the present study, we selected all forms to be semantically transparent, post hoc semantic relatedness ratings by 60 participants indicated that suffixed primes tended to be judged as more like the target than were prefixed primes. On a 7-point scale, the mean relatedness scores (SDs) for suffixed targets were 5.9 (0.7), 2.3 (1.0), 5.2 (0.9), and 1.6 (0.9) with simple, prefixed, suffixed, and unrelated primes, respectively. In a second rating study, we modified the instructions so as to provide an example of antonyms rated as semantically close. Under these instructional conditions, participants rated prefixed and suffixed forms as equivalent.

[5] The structure of pseudowords differed from that of Marslen-Wilson et al. (1994), who did not use illegal combinations of morphemes or pseudobases.

Table 1
Mean Orthographic and Phonological Overlap With Target as a Function of Prime Type

Overlap	Type of prime: Prefixed (*prepay–payment*)	Suffixed (*payable–payment*)	Simple (*pay–payment*)
Stem length in letters	8.2 (1.6)	8.3 (1.5)	5.9 (1.5)
Affix length in letters	2.3 (0.5)	2.5 (0.8)	
Affix length in phonemes	2.3 (0.5)	2.5 (0.8)	
% letters[a]	69.0 (0.1)	68.0 (0.1)	96 (0.1)
% phonemes[b]	64.5 (0.1)	63.2 (0.1)	95 (0.1)
Stress change[c]	3	4	

Note. Standard deviations are in parentheses.
[a] Percentage of recurring letters in prime and target. [b] Percentage of recurring phonemes in prime and target. [c] Incidences of stress change.

were words. In contrast to the design used by Marslen-Wilson et al. (1994), the same word target followed all four types of primes. Participants were randomly assigned to one of the four test orders, and the same practice list of 13 items preceded each experimental list.

Procedure. Auditory items were produced by a female native speaker of English and were recorded with Sound Edit 16 and sampled at a rate of 44.1 kHz. The presentation sequence for Experiment 1A consisted of a fixation point (250 ms),[6] a blank screen for a duration of 50 ms, an auditory prime, and then a visual target at the fixation point. The visual target appeared at the offset of the auditory prime (interstimulus interval = 0 ms), and the intertrial interval was 1,500 ms.

The presentation sequence for Experiment 1B consisted of a fixation point (250 ms), a blank screen for a duration of 50 ms, a visual prime for 250 ms at the fixation point, and then an auditory target. Reaction time was measured from the onset of the auditory target that began at the offset of the visual prime. Because the same target followed all possible primes, problems associated with yoking different targets across conditions were avoided. The intertrial interval was 1,500 ms. In Experiment 1C, visual targets followed after visual primes at an SOA of 250 ms.

The order of items was randomized for each participant, and items were presented on a Macintosh IIci computer. Items in Experiments 1A and 1B were presented in four blocks of 25 items with a 1-min break between blocks. Experiment 1C was run in one block. In each experiment, participants indicated their response by pressing the right button on a keyboard for word and the left button for pseudoword responses.

Results and Discussion

Errors and extreme response times (more than 2 *SD* from each participant's mean) were eliminated from all reaction time analyses. Outliers constituted about 2% of all responses. Data from 2 participants were eliminated from Experiment 1A because of high error rates (>35% in any one condition). No items were eliminated. No data were eliminated from Experiment 1B. Data from 2 participants were eliminated from Experiment 1C because of high error rates (>35%). Table 2 summarizes the mean decision latencies across participants for target words preceded by simple, prefixed, suffixed, and unrelated word primes when only 30% of prime and target were morphologically related.

Experiment 1A. For visual targets preceded by auditory primes, the reduction in target latencies (facilitation) differed following various types of related primes relative to the unrelated-prime condition. The magnitude of target facilitation was numerically greatest following simple primes. It was reduced following prefixed primes and was absent following suffixed primes. Consistent with these differences, with the latency measure, there was a significant effect of prime type, $F_1(3, 171) = 4.79$, $MSE = 3{,}486$, $p < .005$; $F_2(3, 57) = 2.73$, $MSE = 2{,}865$, $p < .05$. The effect of prime type on the error measure was not significant ($Fs < 1$).

Planned comparisons on decision latencies indicated that target (e.g., *payment*) reaction times following simple (e.g., *pay*) primes were significantly faster than those following unrelated (e.g., *usable*) primes, $F_1(1, 171) = 9.80, p < .005$; $F_2(1, 57) = 4.29, p < .05$, and that the difference between target reaction times following prefixed (e.g., *prepay*) primes and unrelated primes just missed significance, $F_1(1, 171) = 3.36, p < .07$; $F_2(1, 57) = 2.58, p < .11$. Targets following suffixed (e.g., *payable*) primes did not differ significantly from those that followed unrelated primes. This finding replicated that of Marslen-Wilson et al. (1994). Finally, in Experiment 1A, the (20-ms) difference in target latencies following prefixed relative to suffixed primes was nearly significant, $F_1(1, 171) = 3.62, p < .06$; $F_2(1, 57) = 3.61, p < .06$.

Like their targets, simple primes and suffixed primes retained their base morpheme in the beginning portion of the word, although only simple primes produced facilitation. Target latencies following simple primes were statistically faster (35 ms) than those following suffixed primes, $F_1(1, 171) = 10.25, p < .005$; $F_2(1, 57) = 5.58, p < .05$. This finding suggests that full nesting of the prime within the target benefited target recognition. In the framework of suffix–suffix interference, the presence of an affix on the prime together with a different affix on the target slowed decision latencies by about 35 ms under AV presentations when both affixes appeared in the same position relative to the common base morpheme. No analyses could be performed on the pseudowords in Experiments 1A–C because different targets appeared in each condition.

Experiment 1B. Morphological relatedness also influenced target decision latencies when visual primes preceded auditory targets. Overall, latencies were numerically larger when targets were auditory than when they were visual. The effect of prime type on decision latencies was significant, $F_1(3, 237) = 18.91$, $MSE = 6{,}340$, $p < .0001$; $F_2(3, 57) = 15.54$, $MSE = 1{,}987$, $p < .0001$.

[6] Marslen-Wilson et al. (1994) also interposed a tone.

Table 2
Mean Lexical Decision Latencies (in Milliseconds) and Percentages Correct for Complex Targets in Experiments 1A–1C

	Type of prime							
	Unrelated (*usable–payment*)		Prefixed (*prepay–payment*)		Suffixed (*payable–payment*)		Simple (*pay–payment*)	
Prime–target modality	RT	% correct	RT	% correct	RT	% correct	RT	% correct
Auditory–Visual	610	88	590	95	611	92	576	88
Facilitation			20	7	−1	4	34[a]	0
Visual–auditory	998	93	942	94	1,026	94	954	93
Facilitation			56[a]	−1	−28[b]	−1	44[a]	0
Visual–visual	628	93	606	94	606	94	594	93
Facilitation			22[b]	1	22[a]	1	34[a]	0

Note. RT = reaction time.
[a] $p < .05$, by participants and by items, using RT measure. [b] $p < .05$, by only participants, using RT measure.

Again, the effect of prime on the error measure was not significant, $F_1 < 1$ and $F_2(3, 57) = 1.29$.

Planned comparisons on decision latencies indicated that, relative to unrelated primes, facilitation following simple (*pay–payment*) primes (44 ms) was significant, $F_1(1, 237) = 11.62, p < .001$; $F_2(1, 57) = 10.39, p < .005$, as was facilitation (56 ms) following prefixed (*prepay–payment*) primes, $F_1(1, 237) = 19.43, p < .0001$; $F_2(1, 57) = 21.0, p < .001$. Counter to all previous results, when primes were visual and targets were auditory, there was inhibition following suffixed (*payable–payment*) primes that was significant only in the analysis by participants, $F_1(1, 237) = 5.06, p < .05$; $F_2(1, 57) = 2.06, p < .15$.

It is important that under visual–auditory (VA) presentation conditions, the difference (84 ms) between target latencies following prefixed and suffixed primes was significant, $F_1(1, 237) = 44.32, p < .0001$; $F_2(1, 57) = 36.23, p < .0001$. Moreover, target latencies following simple primes were statistically faster (71 ms) than those following suffixed primes, $F_1(1, 237) = 32.00, p < .0002$; $F_2(1, 57) = 21.72, p < .001$, suggesting once again that full nesting of the prime within the target benefits target recognition.

Experiment 1C. Analyses of variance indicated that the effect of type of visual prime on visual target latencies was significant, $F_1(3, 111) = 3.77$, $MSE = 2{,}062$, $p < .01$; $F_2(3, 57) = 2.97$, $MSE = 2{,}067$, $p < .05$, such that all types of morphological relatives reduced target recognition times. The effect of prime on the error measure was not significant ($Fs < 1$). The results of planned comparisons on decision latencies indicated that facilitation following simple primes was significantly greater than that following unrelated primes, $F_1(1, 111) = 10.85$, $MSE = 2{,}062$, $p < .005$; $F_2(1, 57) = 8.23$, $MSE = 2{,}067$, $p < .01$. Facilitation following prefixed primes was marginally significant, $F_1(1, 111) = 4.66$, $MSE = 2{,}062$, $p < .05$; $F_2(1, 57) = 3.33$, $MSE = 2{,}067$, $p < .07$. When prime and target were presented visually, suffixed primes also produced significant facilitation, $F_1(1, 111) = 4.43$, $MSE = 2{,}062$, $p < .05$; $F_2(1, 57) = 4.55$, $MSE = 2{,}067$, $p < .05$. Under VV presentation conditions, target latencies following prefixed and suffixed primes generally did not differ significantly nor did latencies following simple and suffixed forms (12 ms).

Difference scores. To gain some perspective on changes in the magnitude of facilitation and inhibition following prefixed and suffixed forms, we computed the difference between target latencies following unrelated and related primes under AV, VA, and VV configurations. For targets (e.g., *payment*) following suffixed primes (e.g., *payable*), for example, mean differences relative to an unrelated baseline ranged from a null effect (−1 ms) in the AV configuration, to marginally significant inhibition (−28 ms) in the VA configuration, to significant facilitation (22 ms) under VV conditions. Following prefixed primes (e.g., *prepay*), mean differences relative to an unrelated baseline ranged from 20 ms in the AV configuration, to 56 ms in the VA configuration, to 22 ms in the VV condition.

One complication noted above is that latencies tended to be long when targets were auditory as compared with when they were visual. Therefore, to offset the differences in unrelated baselines, we computed the proportion of reduction relative to the unprimed baseline. That is, for each type of prime, for each participant (and each item), we calculated the difference in target decision latencies following unrelated and suffixed primes and divided it by the unrelated target decision latency. These ratio values were then entered into an analysis of variance. Results indicated that the magnitude of facilitation for prime type interacted with modality, $F_1(4, 346) = 4.31$, $MSE = .007$, $p < .005$; $F_2(4, 76) = 3.00$, $MSE = .004$, $p < .05$. In addition, the main effect of prime type was significant, $F_1(2, 346) = 15.53$, $MSE = .007$, $p < .0001$; $F_2(2, 38) = 7.12$, $MSE = .006$, $p < .005$. The main effect of modality was not significant. Difference ratio values are plotted in Figure 1.

For each type of prime, we compared the patterns across the three modality configurations (AV, VA, and VV) of prime and target using the ratio measure. Planned comparisons indicated that facilitation following prefixed and simple primes did not change with manipulations of modality. That is, for *prepay–payment* and for *pay–payment* type pairs, the effect of modality configuration was not significant ($Fs < 1$).

By contrast, for *payable–payment* type pairs, the effect of modality configuration was significant, $F_1(2, 173) = 4.10$, $MSE = .013$, $p < .05$; $F_2(2, 38) = 2.88$, $p < .06$. Although the difference between target latencies under VA and AV presentation conditions did not reach significance ($p < .20$), the difference between VA and VV presentations did, $F_1(1, 173) = 8.10$, $MSE = .013$, $p < .005$; $F_2(1, 38) = 4.71$, $p < .05$.

When facilitation was expressed as a proportion of the unprimed baseline condition so as to offset the effect of differing baselines,

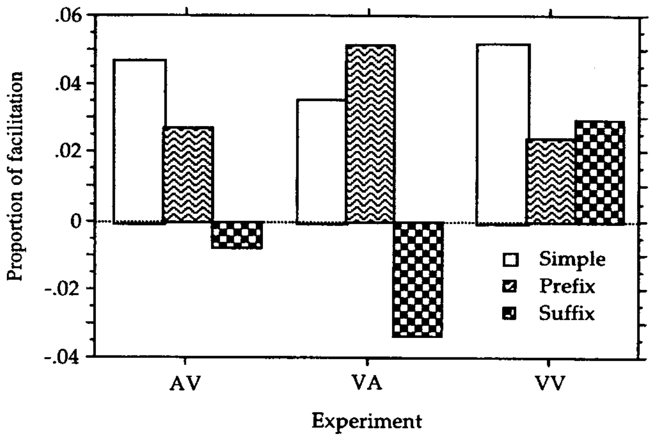

Figure 1. Proportion of facilitation ([unrelated − related]/unrelated) following prefixed, suffixed, and simple primes presented cross-modally. AV = auditory–visual; VA = visual–auditory; VV = visually.

neither the effect of prefixed primes on suffixed targets nor the effect of simple primes on suffixed targets varied with the modality configuration of prime and target. Planned comparisons confirmed that the effect of suffixed primes on suffixed targets was more variable. The significant difference between the VA and the VV results is similar to the outcome reported with morphologically simple forms. In particular, prime–target similarity in the initial positions and dissimilarity at the end, without full nesting of the prime within the target (e.g., *cart–card*), have been found to slow decision latencies with auditory presentations (Radeau et al., 1995).

In summary, the effect of the relative position of a shared base morpheme interacted with modality of presentation such that target decision latencies following prefixed and suffixed primes differed only under cross-modal presentation conditions. When both prime and target were presented visually at SOAs of 250 ms, equivalent facilitation was evident following prefixed and suffixed primes. Under comparable presentation conditions, inhibition arises among forms that are orthographically similar but not morphologically related (Drews & Zwitserlood, 1995; Feldman, 2000). Furthermore, semantically transparent and opaque morphological relatives (matched for orthographic similarity to the target) produce statistically distinct effects at an SOA of 250 ms (Feldman & Soltano, 1999). Consequently, it is unlikely that orthographic similarity can account for equivalent facilitation following prefixed and suffixed primes presented visually.

It is sometimes argued that activation of modality-specific access representations may contribute to facilitation at short lags when prime and target are presented in the same modality (Marslen-Wilson et al., 1994). However, for targets that followed prefixed primes and for those that followed simple primes, the magnitude of facilitation under VV presentation conditions and under AV presentation conditions was remarkably similar. Comparable magnitudes under VV and AV presentation conditions following prefixed (22 ms vs. 20 ms) and simple (34 ms vs. 34 ms) primes are inconsistent with the claim that facilitation to visual targets following visually presented suffixed primes is enhanced by a modality-specific contribution. In conclusion, comparable target facilitation following prefixed and simple primes when presentations are purely visual and when there is cross-modal variation is consistent with a modality-neutral lexical architecture. Results following suffixed primes that differ when presentations are auditory and when they are visual seem to necessitate a modality-specific dimension.

Experiment 2

In Experiment 1, facilitation was equivalent following prefixed, suffixed, and simple forms when prime and target were presented visually in immediate succession. In addition, visual presentations but not cross-modal presentations (neither VA nor AV) produced facilitation between morphologically related suffixed forms. The exploration of VV facilitation at short lags provided evidence against the claim that successive presentations in the same modality could reflect the effects of similar form. In Experiment 2, we examined VV facilitation at long lags. As we noted above, facilitation between morphologically related primes and targets separated by long lags is not sensitive to the orthographic similarity between the prime and the target (Feldman & Bentin, 1994; Feldman & Moskovljević, 1987; Fowler et al., 1985), and morphologically unrelated but orthographically similar pairs tend to produce no effect, at least no facilitation (Feldman, 2000). In essence, a pattern of comparable long-term facilitation following prefixed and simple as well as suffixed primes would be difficult to explain in terms of form-based similarity because effects of orthographic similarity tend to be absent when many items intervene between prime and target.

In addition, we asked whether the rejection of target pseudowords composed of an illegal combination of pseudobase plus affix was impaired by the repetition of the base in prime and target and whether the position of the base relative to the affix was important. There is evidence that position of the morpheme in a pseudoword influences rejection latencies for nonprimed targets (Taft & Forster, 1975, 1976); therefore, priming of pseudoword targets may depend on the position of the pseudobase within the letter string of the prime. Accordingly, we compared recognition latencies for pseudoword targets following suffixed, simple, and prefixed nonword forms.

Method

Participants. Forty-six college students from the same population sampled in Experiment 1 participated in Experiment 2. None had participated in the previous experiment.

Materials. Materials consisted of the same 24 sets of English materials used in Experiment 1 except that the unrelated prime from Experiment 1 was replaced by a prime that was identical to the target.

Twenty-four sets of English pseudoword materials were constructed to resemble the word items in terms of morphological structure. Each pseudoword set included a morphologically complex target (e.g., *ligionable*) and three types of morphologically related primes. The identity prime was identical to the target. The prefixed prime (e.g., *disligion*) was composed of a prefix and the base of the target. The suffixed prime was composed of a different suffix and the base of the target (e.g., *ligionment*). The simple prime (e.g., *ligion*) was composed of the base morpheme alone.

Design. Four test orders each containing 100 items were created. Half of the items were words, and half were pseudowords. Words and pseudowords were presented equally often as primes and as targets. In addition, there were 4 filler items introduced to maintain the requisite prime–target lags. Each test order included six tokens of each of the four types of primes (viz., identity, simple, prefixed, and suffixed), and across four test orders, each target was preceded by all four types of prime. Primes and targets were separated by an average of 10 intervening items (the range was 7 to 13). Participants were randomly assigned to one of the four test orders, and the same practice list of 13 items preceded each experimental list.

Procedure. Materials were presented on a Macintosh SE computer. Each experimental trial consisted of a fixation signal "+" presented for 250 ms, followed by a blank field for 50 ms, and then by the letter string. Items remained visible until the participant responded or until 1,500 ms had elapsed. The intertrial interval was 1,500 ms. Responses to word targets were made by pressing the right lever on a response board with the right index finger. Pseudoword responses were indicated by pressing the left lever with the left index finger.

Results and Discussion

Errors and extreme response times were eliminated according to the same criterion as those used in Experiment 1. Outliers constituted about 3% of all responses. No data from participants or items were eliminated. Table 3 summarizes the mean reaction times over participants for target words and pseudowords preceded by identity, prefixed, and suffixed primes and for the first presentation of those same words as a prime.

Means for targets following each of the four types of primes as well as the no-prime[7] condition were entered into an analysis of variance. Decision latencies revealed that facilitation following prefixed primes and suffixed primes did not differ in magnitude nor did target latencies following suffixed and simple primes. All prime types produced facilitation. For words, the effect of type of prime on target latencies was significant, $F_1(4, 180) = 5.96$, $MSE = 2{,}234$, $p < .0002$; $F_2(4, 92) = 2.78$, $MSE = 2{,}465$, $p < .05$, but the effect of prime type using the error measure was not (both Fs < 1). Planned comparisons based on participant data indicated that responses to targets following prefixed and suffixed primes were significantly faster than those in the no-prime condition. The item analysis missed significance following prefixed but not suffixed primes, $F_1(1, 180) = 6.37, p < .01$; $F_2(1, 92) = 2.27, p < .14$; $F_1(1, 180) = 9.03, p < .003$; $F_2(1, 92) = 5.25, p < .05$, respectively.

The pseudoword results of Experiment 2 revealed nonsignificant inhibition in decision latencies. With the accuracy measure, performance following suffixed primes significantly deteriorated relative to the no-prime condition. However, performance following suffixed and simple primes did not differ. Repetition of the pseudobase in word initial position of prime and target evidently made rejections more difficult.

The analyses of variance confirmed that for pseudoword targets, the effect of type of prime on reaction time was not significant (both Fs < 1), but the effect on errors was significant, $F_1(4, 180) = 3.83$, $MSE = 0.57$, $p < .005$; $F_2(4, 92) = 2.38$, $MSE = 3.42$, $p < .06$. Planned comparisons on error data for pseudoword targets indicated that relative to the no-prime condition, accuracy rates following suffixed primes, $F_1(1, 180) = 11.00$, $p < .001$; $F_2(1, 92) = 4.19$, $p < .05$, but not prefixed primes declined (both Fs < 1). Accuracy rates following suffixed primes and simple primes did not differ significantly. There was, however, a tendency for accuracy rates following primes in the prefixed condition to be higher than those following primes in the suffixed condition, $F_1(1, 180) = 7.64$, $p < .006$; $F_2(1, 92) = 2.45$, $p < .12$.

Morphological structure impaired the accuracy of pseudoword target rejection. In contrast to the pseudowords in typical repetition-priming studies of morphology, pseudoword targets in Experiment 2 were derived from a pseudoaffixed word and could be considered illegal combinations of bound bases and affix. For example, *ligion* was derived from *religion* and *levant* from *relevant.* Therefore, comparisons with pseudoword outcomes in studies that alter the base morpheme may not be appropriate. Target accuracy, but not decision latency, was impaired by repetitions that shared word initial similarity. A position-sensitive detrimental priming effect of morphological structure with pseudowords that share initial similarity may be analogous to the effect of position of the pseudobase in the nonprimed results of Taft and Forster (1975). However, although pseudoword latencies for prefixed forms were more accurate overall, they tended to be slower so that excessive theorizing about differences between prefixed and suffixed pseudoword forms is ill-advised.

The patterns of positive decision latencies in Experiment 2 indicated that, at long lags, simple primes, prefixed primes, and suffixed primes facilitated target decisions in a similar way. Planned comparisons indicated that facilitation was at least as reliable for *payable–payment* prime–target pairs as for *prepay–payment* type pairs. In summary, the long-term repetition-priming results provide no evidence that derivationally suffixed forms are processed differently from other types of morphologically complex forms. That is, when presentations were visual and an average of 10 items intervened between morphological relatives, prefixed primes and suffixed primes produced equivalent facilitation to target decision latencies. Moreover, these results parallel those obtained under visual presentation conditions at a short lag. Accordingly, in the present study, there is no evidence that form-based similarity was responsible for equivalent facilitation following visually presented prefixed and suffixed forms.

General Discussion

In two lexical decision experiments, we looked for evidence that one aspect of sublexical structure, the relative ordering of base morpheme and affix components, affected word recognition. We compared target latencies following prefixed and suffixed primes to ask whether the position of a common base morpheme relative to an affix influenced the magnitude (or the direction) of morphological facilitation (inhibition) over variations of the lexical decision task. The logic underlying this study was that if both base and affix processing are lexical events and if auditory and visual presentations converge onto a common lexical representation, then effects of affix position on morphological facilitation should not change qualitatively according to the modality with which one accesses the lexicon.

Morphological Facilitation and Affix Position

Experiment 1A was modeled after the short-term cross-modal study of Marslen-Wilson et al. (1994), although the design of Experiment 1 improved on several methodological aspects of the original research. First, the same targets followed prefixed and suffixed primes so that the critical manipulation repeated the target rather than the prime. Second, the frequencies of the prefixed and

[7] As is the convention in long-term repetition-priming studies (e.g., Feldman & Fowler, 1987), latencies for unprimed targets were obtained from the first presentation of the target in the identity condition.

Table 3
Mean Lexical Decision Latencies (in Milliseconds) and Percentages Correct for Complex Targets in Experiment 2

	Type of prime									
	None (*payment*)		Identity (*payment–payment*)		Prefixed (*prepay–payment*)		Suffixed (*payable–payment*)		Simple (*pay–payment*)	
Lexicality	RT	% correct	RT	% correct	RT	% correct	RT	% correct	RT	% correct
Words	590	92	542	95	565	95	560	95	561	98
Facilitation			48	3	25[b]	3	30[a]	3	29[b]	6
Pseudowords	727	90	728	83	748	88	733	82	724	85
Facilitation			−1	−7	−21	−2	−6	−8	−3	−5

Note. RT = reaction time.
[a] $p < .05$, by participants and by items, using RT measure. [b] $p < .05$, by only participants, using RT measure.

suffixed primes were matched. Third, the comparison of facilitation following a prefixed prime and following a suffixed prime was made within the same experiment so that planned comparisons provided the basis for theorizing about potential differences between prefixed and suffixed forms.

Marslen-Wilson et al. (1994) reported qualitative differences in recognition latencies to suffixed visual targets following suffixed as contrasted with prefixed auditory primes. The outcome of Experiment 1A replicated their findings. In particular, under auditory prime–visual target cross-modal presentation conditions, neither facilitation nor inhibition to targets was evident for *payable–payment* pairs, although *prepay–payment* pairs tended to facilitate responding. Moreover, in Experiment 1A, we observed a marginally significant ($ps < .06$) difference (20 ms) in target latencies following prefixed as compared with suffixed primes.

When auditory targets followed visual primes (Experiment 1B), *payable–payment* pairs produced inhibition (significant in the analysis by participants and a trend [$p < .15$] in the analysis by items), and *prepay–payment* pairs produced facilitation. Under VA presentation conditions, the difference (84 ms) between target latencies following prefixed and suffixed primes was statistically significant. In distinct contrast to the cross-modal presentation conditions, when visual primes and visual targets were presented at an SOA of 250 ms (Experiment 1C), facilitation was evident for suffixed targets following suffixed as well as prefixed and simple primes. Importantly, the magnitudes of facilitation following prefixed and suffixed primes did not differ. These are presentation conditions under which orthographic similarity produces inhibition rather than facilitation (Drews & Zwitserlood, 1995; Feldman, 2000); therefore, it is unlikely that VV facilitation can be attributed to similarity of form rather than to morphological relatedness. Finally, comparable facilitation in the VV and AV conditions across all prime types reduces the likelihood that similarity of form, or some other factor specific to visual presentations of both prime and target, was operating when both prime and target were visual.

Results following prefixed and suffixed primes also were similar when visual primes and visual targets were separated by long lags (Experiment 2). More specifically, *payable–payment* and *prepay–payment* prime–target type pairs as well as *pay–payment* type pairs produced statistically equivalent facilitation despite variation in the place of overlap between prime and target. This outcome is not surprising, however, because the long-term repetition-priming procedure is relatively insensitive to orthographic overlap.

Marslen-Wilson et al. (1994) introduced the term *suffix–suffix inhibition* for the failure to observe facilitation among suffixed morphological relatives and claimed that the absence of morphological facilitation reflects the existence of inhibitory connections between the plausible suffixes within lexical entries that are morphologically decomposed. Moreover, the conditions for suffix interference could be met only if suffixed primes were presented auditorily, although targets could be either auditory or visual (Marslen-Wilson, Zhou, et al., 1996). In the present study, we examined the generality of this account by introducing either an auditory target or an auditory prime and by comparing the two cross-modal configurations with that of visually presented primes and targets. The outcome of our study calls into question claims about facilitation in the cross-modal presentation procedure and its locus in a lexical architecture that is neutral with respect to modality of presentation.

Suffix–Suffix Interference: Lexical Architecture or Modality-Specific Process?

Latencies to auditorily presented targets were longer than to visually presented targets. To control for differences in unrelated baseline latencies across the differing modality configurations, we transformed the facilitation measure into a proportion of reduction in decision time. Proportion of facilitation following neither prefixed nor simple primes changed over the modality configuration of prime and target. The pattern is depicted in Figure 1 and is consistent with a lexical locus for morphological facilitation. However, recognition latencies following suffixed primes exhibited a more complex and modality-dependent pattern. The net percentage of facilitation from repetition of the base morpheme and interference from appropriate suffixes that were not presented on the prime was essentially null (−0.8%) when targets were visual and primes were auditory in Experiment 1A. By contrast, in Experiment 1B, when targets were auditory and primes were visual, there was (statistically marginal) inhibition (−3.4%). In Experiment 1C, when both prime and target were visually presented, decision latencies were facilitated (3.0%).

In sum, the failure to find short-term facilitation between morphologically related suffixed primes and suffixed targets generalized to conditions in which either prime or target was presented auditorily. Planned comparisons revealed that VA and VV suffix inhibition were statistically different whereas AV and VV were not. In effect, the VV pattern was more similar to the AV pattern than to the VA pattern. Stated generally, the modality of the target appears to be crucial to replicate Marslen-Wilson et al.'s (1994) absence of facilitation among suffixed morphological relatives.

Despite our replication in Experiment 1A of Marslen-Wilson et al.'s (1994) finding, the present data do not provide compelling evidence that the cross-modal priming task taps into a lexical architecture that is modality-neutral. If access were to a shared lexical architecture, then AV and VA configurations would have produced similar patterns of morphological facilitation and inhibition. When inhibition was expressed as a proportion of the baseline, patterns across modality configurations were comparable following prefixed and simple primes, but patterns of morphological facilitation following suffixed primes were not. Under the VA configuration, a suffixed prime produced an effect that was statistically significant and negative, whereas under the AV configuration, the effect was statistically and numerically null. Unfortunately, the comparison of VA and AV suffix–suffix conditions did not reach significance ($p < .20$). It is important to acknowledge, however, that the failure to obtain significance may indicate that sensitivity was compromised because the critical comparison was between participants. If the VA and AV suffix–suffix outcomes do in fact differ, the conclusion is that the cross-modal priming task does not access a modality-neutral lexical architecture.

An alternative interpretation is that the locus of suffix–suffix interference is not lexical. Morphological facilitation fails to arise when targets (and perhaps primes) are presented auditorily; this finding suggests a modality-specific contribution. Accordingly, interference among suffixed morphological relatives could be attributed to mismatches in word final position when presentations of target (or prime) are auditory. This portrayal is appealing because it would obviate the need for positing differing types of lexical representations or linkages between the prefixes and suffixes that can combine with a particular base morpheme to account for the finding (Marslen-Wilson et al., 1994) that prefixed primes produce morphological facilitation for suffixed targets whereas suffixed primes do not. The plausibility of a modality-based interpretation of suffix–suffix interference is buttressed by the similarity of the pattern of inhibition for morphologically simple and for morphologically complex forms.

As we noted in the introduction, in auditory recognition tasks with short intervals between prime and target, the effect of word final mismatches between morphologically unrelated and simple targets and primes was more detrimental than the effect of mismatches earlier in the word (Radeau et al., 1995). Mismatches were defined by the addition of a component at the end of the prime so that *cart–card* pairs but not *car–cart* type pairs (with a full nesting of the prime within the target) constituted a mismatch and slowed performance. A more crucial finding is that significant inhibition has also been reported for cross-modal presentations of (word initial) orthographically similar but morphologically unrelated pairs, such as *vintage–vindicate* (Marslen-Wilson, Ford, Older, & Zhou, 1996). In the present study, we observed that the pattern for morphologically complex prime–target pairs, such as *payment–payable,* tended to vary over different modality configurations. In particular, the presence of a mismatching component in word final position of the prime (e.g., *ment* vs. *able*) slowed recognition latencies under cross-modal presentations when either the prime or the target was auditory. The parallel between suffix–suffix interference and the interference associated with auditory presentations of morphologically simple or unrelated word pairs such as *vintage–vindicate* is striking.

To summarize, for *payment–payable* type pairs, as for *vintage–vindicate* as well as *cart–card* type pairs, mismatches in word final position were detrimental to performance whenever a portion of the prime–target presentation sequence was presented auditorily. Conversely, facilitation arose for *payment–payable* type pairs presented visually, and it is implausible that the effect reflects orthographic similarity because, under comparable experimental conditions, inhibition has been documented for orthographically similar forms that are not morphological relatives. In conclusion, the direction as well as the magnitude of the influence of suffixed primes on morphologically related suffixed targets appears to vary with the modality configuration of prime and target, and the constraint of modality on suffix–suffix inhibition calls into question its lexical locus.

All of the research in the present article as well as in that of Marslen-Wilson et al. (1994) was conducted with English materials and native speakers of English. Morphological processing may vary across languages according to the special properties of morphemes within a language (e.g., Plaut & Gonnerman, 2000; Schreuder & Baayen, 1995). On the basis of a series of experiments in English, Marslen-Wilson et al. (1994) suggested that morphological relatives must be semantically similar (transparent) for effects of morphological structure to be evident. In Hebrew, by contrast, morphological facilitation among words that share a base or root morpheme has been demonstrated among relatives with only minimal semantic similarity (Bentin & Feldman, 1990; Frost, Forster, & Deutsch, 1997). In a similar manner, Marslen-Wilson et al. (1994) argued that priming following prefixed and suffixed forms differs under cross-modal presentation conditions. In Hebrew, however, decision latencies for suffixed visual targets show equivalent morphological facilitation following auditory presentations of prefixed and suffixed primes (Raveh & Feldman, 1998). Claims about processing asymmetries between prefixed and suffixed forms ultimately need to be systematically evaluated in a variety of languages as well as in a variety of modality configurations and tasks so that language universals as well as the idiosyncrasies of particular languages and of particular tasks can be reconciled.

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Appendix

Materials Used in Experiments 1 and 2

Simple	Prefixed	Suffixed	Target
act	react	actor	action
agree	disagree	agreeable	agreement
calculate	miscalculate	calculator	calculation
civil	uncivil	civilize	civilian
complete	incomplete	completion	completely[a]
correct	incorrect	correction	correctly
create	recreate	creator	creation
equal	unequal	equality	equally
formal	informal	formality	formally
happy	unhappy	happily	happiness
honor	dishonor	honorary	honorable
mature	premature	maturely	maturity
mobile	immobile	mobilize	mobility
mortal	immortal	mortally	mortality[a]
move	remove	mover	movement
normal	abnormal	normalcy	normally
pay	prepay	payable	payment
perfect	imperfect	perfection	perfectly
popular	unpopular	popularly	popularity[a]
real	unreal	realism	really
regular	irregular	regularity	regularly
respect	disrespect	respectful	respectable
similar	dissimilar	similarity	similarly
violent	nonviolent	violently	violence[a]

[a] Missing from Experiment 1.

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