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Equivalent Effects of Inflected and Derived Primes: Long-Term Morphological Priming in Fragment Completion and Lexical Decision

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Previous studies of long-term morphological priming have obtained a mixed pattern of results: Although some studies have found larger effects of inflected primes than of derived primes, others have found that inflections and derivations have equivalent effects. We reexamined this issue in four experiments in which the inflected and derived primes were paired with the same target words (e.g., *believe, believed, believer*) and were equated in terms of their orthographic similarity to the targets. Across these experiments, inflections and derivations consistently produced equivalent levels of priming, both in the word fragment completion task (Experiments 1 and 3) and in the lexical decision task (Experiments 2 and 4). The implications of these findings for current models of the processing of morphologically complex words are discussed.

Key Words: morphological priming; inflection; derivation; fragment completion; lexical decision.

One of the characteristics that makes human language powerful is its compositionality. Morphology constitutes one level of compositionality, that of combining morphemes, the smallest units of meaning, into complex words. In the past three decades, the processing of morphologically complex words has received considerable attention in psycholinguistic investigation. Evidence that morphological constituents play a role in word recognition has been obtained in a variety of tasks and in a variety of languages (see Bentin & Frost, 1995; Chialant & Caramazza, 1995; Sandra, 1994; and Stolz & Feldman, 1995; for reviews).

Whereas it is uncontroversial that morphological structure plays a role in lexical processing, how this structure is captured and manipulated is still a matter of debate. One aspect of this debate concerns the psychological reality of linguistic distinctions among morphologically complex words. Based on the observation that inflections and derivations differ considerably with respect to their syntactic and semantic functions, linguists have traditionally treated these formations as distinct lexical categories (e.g., Anderson, 1982; Aronoff, 1976; Perlmutter, 1988). Inflections (e.g., case marking, number and person agreement) comprise a closed and paradigmatic set of forms—all possible forms usually exist for each base word, and which form is used is dictated by the syntactic structure of the sentence in which it appears. Derivations, in contrast, are neither regular nor predictable; they typically change the syntactic class of the base word, and they participate in the formation of new words (e.g., nature → natural → naturally). Furthermore, inflected and derived forms differ considerably in their semantic properties. The relationship between the meaning of an inflected word and the meaning of its constituent morphemes is transparent and consistent (e.g., *cat–cats, dog–dogs*). In contrast, because derivational affixes often change the meaning of base morphemes in idiosyncratic ways (e.g., *generate–generation* vs *congregate–congregation,* and *bake–baker* vs *cook–cooker,* examples taken from Henderson, 1985), the relationship between the meaning of a derived word and the meaning of its constituent morphemes is relatively unpredictable.

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It has often been argued that the linguistic distinction between inflections and derivations is honored in the manner in which morphologically complex words are represented and processed (Henderson, 1985; Pinker, 1991; Pinker & Prince, 1991; Stanners, Neiser, Hernon, & Hall, 1979; Taft, 1985, 1994). For example, some accounts (e.g., Stanners et al., 1979) hold that derivational forms are explicitly stored in the lexicon, but (regular) inflected forms are not. According to these accounts, inflected words, by virtue of their paradigmatic nature and semantic predictability, are perceived and produced by applying rule-governed computations to the representations of their constituent morphemes. In contrast, given the semantic unpredictability of derived forms, rule-goverened computations would be exceptionally costly and error-prone (e.g., Henderson, 1985; Jackendoff, 1975). As a consequence, the processing of derived words must rely on stored whole-word representations. On this view, the processing of inflected and derived forms relies on two qualitatively distinct mechanisms: rule-governed computation and lexical look-up.

Many empirical results support the view that inflections and derivations are represented and processed differently. For example, studies of speech production have revealed that erroneous shifts of affixes are much more common for inflectional than derivational affixes in the speech of both intact (e.g., Garrett, 1980) and brain-damaged speakers (e.g., Miceli & Caramazza, 1988). Similarly, studies investigating language comprehension, and in particular the recognition of single words, have shown different findings for inflected and derived words (see Taft, 1985 for a review). For example Feldman (1994) found that although inflectional affixes are more rapidly segmented from truly affixed than from pseudoafixed words, derivational affixes are not. Similarly, Smith and Sterling (1982) observed that letters were missed more often in a letter cancellation task when they were embedded in inflectional affixes than when they were part of derivational affixes.

Among the methodologies used to compare the processing of inflected and derived words, perhaps the most common is repetition priming. In general, studies employing this paradigm have found that the identification of a work is facilitated not only by the prior presentation of that word, but also by the prior presentation of a morphologically related word. For example, the identification of *car* is facilitated when preceded either by itself or by the morphologically related *cars* (e.g., Murrell & Morton, 1974). Morphological priming has been obtained with a variety of languages and occurs over and above the effects of either form priming or semantic priming (see Feldman, 1994, and Tenpenny, 1995, for reviews).

The first study to use the repetition priming paradigm to compare the processing of inflections and derivations (and one that served as the prototype for numerous subsequent studies in experimental logic and design) was conducted by Stanners et al. (1979). They found that lexical decisions were facilitated when base-form targets were preceded by inflected primes (e.g., *pours–pour*) and that this effect was equal in magnitude to identity priming (e.g., *pour–pour*). In contrast, the priming effect from suffixed derivations (e.g., *appearance–appear*) [as well as from irregular inflections (e.g., *hung–hang*)], although statistically significant, was smaller than the identity priming effect.

This pattern of results led Stanners et al. to hypothesize that different mechanisms underlie the priming effects for (regular) inflections and derivations. According to their account, the full priming found for regular inflected forms indicates that these forms are recognized by first parsing the whole word into its morphenic constituents (cf., Taft & Forster, 1975) and then accessing the lexical representation of the base word. Hence, identical and inflected primes give rise to equivalent magnitudes of priming because in both cases the same access unit is activated by the prime and the target. In contrast, the partial priming found for derivations (and irregular inflections) was taken to indicate that these forms are not parsed into their constituent morphemes and are instead recognized by accessing whole-word representations in the lexicon. Priming in this case was taken to be the result of activation spreading along interconnections between the representations of morphologically related words.

Although several subsequent studies have found that inflections are more effective morphological primes than derivations, other results suggest that this is not always the case. Several studies conducted in Serbian (Feldman, 1991, 1994; Feldman & Fowler, 1987; Feldman & Moskovljevic, 1987) have replicated the pattern found by Stanners et al. (1979), finding that inflections produced more priming than derivations. In contrast, methodologically similar studies conducted in Italian (Burani & Laudanna, 1987, cited in Burani & Laudana, 1992) and Hebrew (Feldman & Bentin, 1994) found equivalent levels of priming by inflectionally and derivationally related words. These contrasting results could perhaps be due to language-specific differences in the morphological organization of the lexicon. However, language differences cannot be the whole story, because conflicting results have also been observed among studies using English materials. Specifically, whereas Stanners et al. (1979) and Fowler, Napps, and Feldman (1985, Experiment 1) found that English base words were primed more strongly by inflections than be derivations, Fowler et al. (1985, Experiment 2) and Napps (1989) observed equivalent levels of priming in the two conditions. In the present study, we tried to resolve some of these inconsistencies.

An examination of the English studies suggests that some of the discrepancies among their results may be attributable to methodological factors. For example, in several of these studies (Stanners et al., 1979; Fower et al., 1985, Experiment 2) the effects of inflected and derived primes were assessed in separate experiments or conditions involving different target words. Because differences in the frequencies of the targets (and perhaps other factors, such as the average lag between the prime and the target) led to considerable variability in the magnitude of identity priming across these conditions, it is difficult to assess whether the observed relationship between inflectional and derivational priming reflects the manner in which morphologically related words are represented or processed or whether the effects of other variables obscured (or artifically created) a different in the effectiveness of inflected and derived primes.

One solution to this problem is to compare the effects of inflected and derived primes using the same targets (e.g., *adjusts–adjust* vs *adjustment–adjust*) in circumstances where all other variables (e.g., prime-target lag) are held constant. However, even in these circumstances ambiguities can arise about how the effects of inflected and derived primes should be compared. For example, when Fowler et al. (1985, Experiment 1) assessed the effects of inflected and derived primes relative to an unprimed baseline condition, the priming effect from inflections (54 ms) was significant, whereas that of the derivations (28 ms) was not. Based on this comparison, inflections and derivations appear to differ in their effectiveness as primes. On the other hand, response times in the derived-prime condition were not statistically different from those of either the inflected-prime condition or the identity-prime condition. Looked at in this way, priming from derivations not only can be termed "full" but also appear to be comparable to that from inflections. Thus, the interpretation of the results depends on how the effects of inflected and derived primes are compared.

Another factor complicating the interpretation of the studies under consideration is orthographic similarity. In each of these studies, morphological relationship was confounded with orthographic similarity, such that inflected primes were on average more similar to their targets than were derived primes (e.g., *pours–pour* vs *selective–select,* in Stanners et al., 1979; *adjusts–adjust* vs *adjustment–adjust,* in Fowler et al., 1985). Although morphological priming cannot be attributed solely to the orthographic similarity between the prime and the target (e.g., Stolz & Feldman, 1995), orthographic similarity does modulate the effects of morphological priming (Rueckl, Mikolinski, Raveh, Miner, & Mars, 1997). Together with the other issues raised above, this fact raises doubt about whether differences between inflection and derivation priming, when found, were due to differences in the morphological relationships between the primes and the targets or whether they were the consequence of other factors.

Given the equivocal nature of the extant literature comparing inflected and derived primes, and given too the theoretical significance of this issue, the purpose of our study was to reexamine whether English inflections and derivations differ in the degree to which they prime their base forms. The design of our experiments was shaped by several considerations. First, in light of the issues raised above, inflected and derived primes were paired with the same target words, and the effects of these primes were contrasted within each experiment. In addition, because morphological priming varies with the orthographic similarity between the prime and its target (Rueckl et al., 1997), the inflected and derived primes were equated on this dimension. Finally, we decided to widen the range of tasks that have been used to investigate morphological priming effects. Priming in this study was measured in two different tasks: the lexical decision task (Experiments 2 and 4) and the fragment completion task (Experiments 1 and 3). By using two measures of priming we hoped to gain additional insight about the processes of morphological priming. If both tasks reveal the same effects, we gain confidence that these effects reveal something fundamental about the processes that underlie word identification. If different tasks give rise to different patterns of effects, an analysis of the differences could shed light on the loci of these effects.

EXPERIMENT 1

Investigations of morphological priming in general, and of priming by inflections and derivations in particular, have relied almost exclusively on facilitation in the lexical decision task as a measure of priming. In contrast, the investigation of repetition priming within the domain of memory research has employed a variety of tasks, including tachistoscopic identification, stem completion, fragment completion, and category exemplar generation. As research in this domain has shown, converging evidence across a variety of tasks not only supports the reliability of the priming effects but also contributes to our understanding of the processes that underlie these effects (see Roediger & McDermott, 1993, and Schacter, 1992, for reviews).

In Experiment 1 we used the fragment completion task to examine morphological priming effects involving English inflections and derivations. In the fragment completion task, participants see a word fragment (e.g., *_ake*) and are asked to respond with a word that completes it (e.g., *bake*). Several previous studies have demonstrated that morphological priming influences performance in this task (Rueckl et al., 1997; Weldon, 1991). In the present experiment the morphological primes included both regular inflections (e.g., *baked*) and derivations (e.g., *baker*), and the inflected and derived primes were matched in terms of orthographic similarty to their targets. At study, participants were presented with the primes and made a semantic judgment about them. After a filler task was completed, the fragment completion task was performed. The dependent measure was the proportion of fragments completed with target words.

Method

Participants. Students at the University of Connecticut participated in this and the following experiments in fulfillment of a course requirement. All were native speakers of English. Sixty-four students participated in this experiment.

Design and materials. Priming condition was a within-subjects variable. There were four priming conditions: identity priming (e.g., *boil–boil*), inflection priming (e.g., *boiled–boil*), derivation priming (e.g., *boiler–boil*), and an unprimed condition, in which no related primes were presented during the study phase.

Fifty-six word triplets were prepared (see Appendix A). Each triplet included a base form and two different morphologically related forms of that word, an inflection and a derivation (e.g., *bake, baked, baker,* respectively). The inflection suffixes were *-s,* (18), *-ed* (20), and *-ing* (18). The derivational suffixes were *-er* (20), *-y* (18), *-ery* (8), *-age* (6), *-ful* (1), *-ist* (2), and *-ure* (1). To control for the orthographic similarity of the inflections and derivations to their targets, the inflected and derived forms in each triplet were matched on the length of their suffix (e.g., if *-s* was used as an inflection suffix then *-y* was used as the derivational suffix and similarly for the 2- and 3-letter suffixes). Hence, the orthographic similarity of the two types of morphological relatives to the target was equated. In addition, the selection of inflections and derivations was constrained such that they were (a) relatively semantically transparent (i.e., they were highly related in meaning to the base form target: thus, pairs like *department–depart* were not included) and (b) orthographically and phonologically transparent [i.e., the suffixed form preserved both the spelling (except for a few omissions of final *e*) and the pronunciation of the base word; thus, pairs like *division–divide* were not included in the materials]. The target (base form) words were 3–5 letters long and had a mean frequency (Kucera & Francis, 1967) of 142 (medium 46, range 1–2244); the inflected primes were 6.1 letters long on average and had a mean frequency of 29 (median 10, range 0–159); and the derivational primes had an average of 6.1 letters and a mean frequency of 11 (median 4, range 0–89).

To prepare the test fragments, one or two letters of each of the 56 stem targets were removed and replaced by underlined blanks (e.g., *_ake*). Letters were eliminated from initial, medial, and final positions. Each resulting fragment had at least three possible completions, of which the stem target was not the highest in frequency (e.g., for the fragment *_air,* the possible completions are the target *hair* and also *pair, fair,* and *lair*). In addition to the experimental stimuli, 45 filler words, three to six letters long with a mean frequency of 124 (median 50, range 2–807) were prepared for the study task. The stimuli for the filler task consisted of 15 fragmented words in which all but the first two letters were removed, and the length of the required completion was specified as either "short" or "long" [e.g., at _ _ _(long)]. None of the fillers or the possible completions for the filler fragments were included in the experimental stimuli. Words and fragments were presented in the middle of the computer screen, appearing black on white in bold extended lowercase 18-point Courier font.

To counterbalance the stimuli across priming conditions, the 56 triplets were partitioned into four sublists of 14 triplets each. During the study phase, a participant was presented with the base form targets form one of the sublists, the inflections from a second sublist, and the derivations from a third sublist. No words from the fourth sublist were presented during the study, and therefore the completion rate for the targets from this sublist provided a measure of baseline performance. The sublists were rotated through priming conditions such that each triplet was assigned to each priming condition equally often across subjects.

Procedure. Participants were tested individually or in groups of 2 or 3 in a quiet room. They were told that they would complete three different tasks investigating different aspects of word knowledge. The experiment began with a study task in which participants were instructed to classify each presented word to one of three meaning categories: (1) "the word described what one might do," (2) "the word described what one might have," and (3) "the word describes what one might be." An example was given for each of these categories. The participants were given a fourth response category (0), to be used sparsely, if they though a word could not be assigned to any of the three categories. The participants responded by pressing the respective number keys on the keyboard. During the study task, 87 words were presented for classification, of which 42 were experimental primes (14 base forms, 14 inflections, and 14 derivations) and 45 were fillers. The words were randomly ordered and presented in a fixed pace of 4 s per word with a 1-s intertrial interval.

The second task was a filler task in which the participants were presented with the first two letters of 15 words together with a general specification of length [e.g., ab_ _ _ (long), or ti_ _ _ (short)]. They were instructed to type the first word that came to their mind with the given first letters and three or four letters long (for the "short" length) or five or more letters (for the "long" length).

Subsequently, the participants performed the test fragment completion task. They were instructed to type the first word that came to mind

TABLE 1

Target Completion Rate (and Standard Deviation) as a Function of Priming Condition in the Fragment Completion Tasks (Experiments 1 and 3)

	Priming condition			
Experiment	Identity	Inflection	Derivation	Unprimed
Experiment 1				
M	.391	.345	.336	.244
SD	(.136)	(.122)	(.127)	(.113)
Experiment 3				
M	.525	.453	.445	.278
SD	(.197)	(.152)	(.174)	(.151)

and was a legal completion of the presented fragment. On each trial, a fragment appeared and remained on the screen until the participant clicked the mouse. Then a dialog box appeared and the participant typed the whole word. The fragment remained on the screen while the word was typed. If no response was made within 10 s, the message "trial over" was presented and the next fragment appeared 2 s later. The stimuli in this task were the 56 fragmented targets presented in a different random order for each participant. The presentation of the stimuli and the recording of the typed fragment completions were controlled by a computer program. The three tasks were completed on average in 30 min.

Results and Discussion

The target completion rates (i.e., fragment completions that were identical to the target) in the different priming conditions are shown in Table 1. As can be seen from the table, the proportion of target completion varied as a function of priming condition and was highest in the identity priming condition, followed by the inflection, derivation, and unprimed conditions in that order. An analysis of variance (ANOVA) revealed that the effect of priming condition was significant by both subjects [$F_1(3,63) = 15.79$, $MSe = .02$, $p < .0001$] and items [$F_2(3,55) = 16.62$, $MSe = .01$, $p < .0001$]. A series of t tests showed, first, that all three priming effects were significant. That is, for all prime types, targets were more likely to be given as a completion when the fragment was primed by a related word then when it was not primed. This was true by both subjects and items: for identity priming [$t_1(63) = 6.16$, $p < .0001$; $t_2(55) = 6.86$, $p < .0001$], for inflection priming [$t_1(63) = 4.47$, $p < .001$, $t_2(55) = 5.36$, $p < .0001$], and for derivation priming [$t_1(63) = 4.57$, $p < .0001$; $t_2(55) = 3.82$, $p < .001$]. Second, the target completion rate was significantly higher in the identity condition than in the inflection condition [$t_1(63) = 2.11$, $p < .05$; $t_2(55) = 2.26$, $p < .05$] and also significantly higher than in the derivation condition [$t_1(63) = 2.70$, $p < .01$; $t_2(55) = 2.40$, $p < .05$]. Finally, the inflection and derivation conditions did not differ from one another [$t_1(63) = .40$, $p = .70$; $t_2(55) = .45$, $p = .66$], indicating that different morphological relations among the primes and targets yielded equivalent levels of priming.

Several conclusions can be drawn from these results. First, both identity priming and morphological priming influenced performance in the fragment completion task. This is consistent with two previous studies that found morphological priming by irregular inflections (Rueckl et al., 1997) and compounds (Weldon, 1991) in fragment completion. Second, the morphological priming effects were smaller than the effect of identity priming. Third, and most important, the effect of the derived primes (relative to the baseline condition) was statistically (and almost numerically) equal to that of the inflected primes, and both forms of morphological priming were weaker than identity priming. Thus, the results of the first experiment provide no evidence supporting the claim that inflections and derivations are represented or processed in fundamentally distinct ways.

EXPERIMENT 2

In Experiment 2, we asked whether the pattern of effects found in Experiment 1 (i.e., equivalent levels of priming by inflections and derivations) would also be obtained in the lexical decision task. Because previous experiments comparing long-term priming by inflections and derivations used the lexical decision task, combining this task with the materials of Experiment 1 provides a more direct comparison between those studies and our own. As in most of those previous studies, the lag between the prime and the target words was an average of 10 intervening trials. However, unlike the studies of Stanners et al. (1979) and Fowler et al. (1985), in this experiment inflected and derived primes of the same targets were directly compared and orthographic similarity was controlled.

Method

Participants. Seventy-six students participated in this experiment.

Design and materials. The same 56 word triplets from Experiment 1 were used in Experiment 2. Primes and targets were presented in a continuous list and participants performed the lexical decision task.

In addition to the 56 word triplets, 56 pseudo-word triplets were constructed in a manner similar to the word triplets. Each pseudo-word base form was a pronounceable string that was generated by changing one letter of a real English word. For each pseudo-word base form, a pseudo-inflected form and a pseudo-derived form were constructed by adding inflectional and derivational suffixes of matched length (e.g., *binch–binching–binchery*). (The pseudoword triplets are listed in Appendix B).

The word and pseudo-word triplets were used to prepare a continuous list for the lexical decision task. The list included 56 word targets, 56 pseudo-word targets, 56 word primes, and 56 pseudo-word primes. The primes consisted of base forms (identity priming condition), inflections (inflection priming condition), and derivations (derivation priming condition) in equal numbers. The first occurrence of the base form served as the measure of baseline performance (unprimed condition). The items were divided into two blocks. Within each block, words and pseudo-words were arranged in a quasi-random order with 8–13 intervening items between primes and targets. Fourteen filler words were added in order to maintain the required lags. In addition, a practice list of 20 items (10 words, 10 pseudo-words) was constructed. Thus, each participant was presented with a total of 258 items. The stimuli were presented on a computer screen as in Experiment 1.

To counterbalance the stimuli across priming conditions, the 56 triplets were partitioned into three sublists, two with 19 triplets and one with 18 triplets. The assignment of triplets to the priming conditions was counterbalanced across three groups of participants. In addition, the order of items within the blocks (three different orders) and the order of presentation of the two blocks (two different orders) were counterbalanced across participants, resulting in a total of 18 different experimental lists.

Procedure. The participants were tested individually or in groups of 2 or 3 in a quiet room. They were presented with strings of letters and were instructed to decide as quickly and accurately as possible whether each string was an English word. Participants pressed the M key on the computer keyboard with the right index finger for a "word" decision and the V key with the left index finger for a "not a word" decision. The experiment began with the practice list followed by the two experimental blocks. The participants cold take a short rest between the two blocks. The session lasted approximately 20 min.

Each trial began with the presentation of a visual fixation signal (####) at the middle of the screen for 500 ms followed by an interval of 500 ms. Then the string of letters appeared and remained on the screen until the participant responded. If the response was incorrect, the participant received auditory feedback (a 150-ms tone heard through headphones). After the stimulus disappeared, there was 1-s interval that was followed by the fixation signal of the next trial. The stimulus presentation and the on-line recording of the responses were controlled by computer.

Results and Discussion

Incorrect responses and responses that were slower than 2000 ms or faster than 200 ms were excluded from the response time analysis. Outliers accounted for less than 0.2% of all responses and the overall mean error rate was 1.9%. The data from one participant were ex-

TABLE 2

Mean Reaction Times (ms) and Error Rates (%) for the Base Form Targets as a Function of Priming Condition in the Lexical Decision Tasks (Experiments 2 and 4)

	Priming condition			
Experiment	Identity	Inflection	Derivation	Unprimed
Experiment 2				
Reaction time				
M	579	585	592	615
SD	(98)	(100)	(104)	(107)
Error				
M	1.3	1.8	1.7	3.0
SD	(2.5)	(3.6)	(3.0)	(4.2)
Experiment 4				
Reaction time				
M	583	606	599	627
SD	(92)	(111)	(90)	(101)
Error				
M	1.0	2.3	1.9	5.3
SD	(2.8)	(3.8)	(4.0)	(5.3)

cluded from the analyses because of near-change performance.

Response times. The mean response times for the different priming conditions are shown in Table 2. Response times varied as a function of priming conditions and were fastest in the identity priming condition, followed by the inflection, derivation, and unprimed conditions in that order. An ANOVA revealed that the overall effect of priming condition was significant by both subjects [$F_1(3.74) = 14.98$, $MSe = 1226.64$, $p < .0001$] and items [$F_2(3,55) = 13.13$, $MSe = 1124.99$, $p < .0001$]. A series of t tests showed, first, that all three priming effects were significant. That is, lexical decisions for the targets were faster when targets were preceded by identical or related primes than when no related prime was seen earlier in the list. This was true by both subjects and items: for identity priming [$t_1(74) = 5.33$, $p < .0001$; $t_2(55) = 6.04$, $p < .0001$], for inflection priming [$t_1(74) = 4.80$, $p < .0001$; $t_2(55) = 4.77$, $p < .0001$], and for derivation priming [$t_1(74) = 3.69$, $p < .001$; $t_2(55) = 4.05$, $p < .001$]. Second, response times for the identity priming condition were significantly faster than for the derivation priming condition ($t_1(74) = 2.31$, $p < .05$; $t_2(55) = 2.18$, $p < .05$] but not significantly different from the inflection priming condition [$t_1(74) = 1.11$, $p = .27$; $t_2(55) = .89$, $p = .38$]. Finally, as in Experiment 1, the inflection and derivation conditions were not significantly different from one another [$t_1(74) = 1.63$, $p = .11$; $t_2(55) = 1.17$, $p = .25$].

Error rates. The mean error rates for the different priming conditions are shown in Table 2. The pattern of errors resembled that of the response times. That is, the mean error rate varied as a function of priming condition and was lowest in the identity priming condition, followed by the inflection, derivation, and unprimed conditions in that order. An ANOVA revealed that the effect of priming condition was significant by both subjects [$F_1(3,74) = 4.14$, $MSe = .001$, $p < .01$] and items [$F_2(3,55) = 3.56$, $MSe = .001$, $p < .05$]. A series of t tests showed that all three priming effects were significant by both subjects and items: for identity priming [$t_1(74) = 3.03$, $p < .01$; $t_2(55) = 3.13$, $p < .01$], for inflection priming [$t_1(74) = 2.00$, $p < .05$; $t_2(55) = 2.18$, $p < .05$], and for derivation priming [$t_1(74) = 2.25$, $p < .05$; $t_2(55) = 1.99$, $p = .051$]. Although the identity priming effect was numerically larger than the morphological priming effects, it was not significantly different from either the inflection priming effect [$t_1(74) = 1.26$, $p = .21$; $t_2(55) = .96$, $p = .34$] or the derivation priming effect [$t_1(74) = 1.02$, $p = .31$; $t_2(55) = .90$, $p = .37$]. Finally, the inflection and derivation priming conditions were not significantly different from one another [$t_1(74) = .18$, $p = .86$; $t_2(55) = .13$, $p = .90$].

The present pattern of results resemble that of Experiment 1 in several aspects. Identity priming and morphological priming influenced performance in both experiments, even though different tasks were used to assess priming. In addition, in each experiment a direct comparison of performance in the inflection and derivation conditions suggests that inflections and derivations produced equivalent levels of priming. However, the results of the two experiments do diverge in one respect. In Experiment 1, the inflection and derivation priming effects were both smaller than the identity priming effect. In Experiment 2, although the effect of derivation priming was again statistically smaller than that of identity priming, the effect of inflection priming was statistically "full" relative to the identity priming effect.

Thus, in some respects the results of this experiment resemble those of Fowler et al. (1985, Experiment 1). As noted earlier, there is some ambiguity about how this pattern of results should best be interpreted. Specifically, the fact that inflected primes were statistically as effective as identity primes, in conjunction with the fact that derivational priming was statistically weaker than identity priming, suggests that inflected primes have stronger effects than derived primes. On the other hand, the difference in mean response time between the derivation and the inflection priming was small (7 ms) and nonsignificant; this direct comparison indicates that inflected and derived primes had equally strong effects. Several considerations suggest that the latter interpretation is the more appropriate: It involves a more direct comparison, and it is more consistent with the results of the first experiment, which used the same stimuli as the present experiment. These points being notes, the resolution of this issue is best put off until the results of the remaining experiments are reported.

EXPERIMENT 3

In the following experiments we replicated Experiments 1 and 2 with a different set of stimuli. As is typical of many English words, some of the stimuli in Experiments 1 and 2 were semantically ambiguous, and often the alternative interpretations differed in syntactic class (e.g., *pack, love,* and *jumps* can each be interpreted as either a noun or a verb). Because the experimental words are presented in isolation, it is difficult to control which interpretation a reader will choose, and in some cases the interpretation may not be the one intended by the experimenters. For example, we intended *pack* and *packed* to be read as verbs, and thus *packed* was treated as an inflected prime for *pack.* Suppose, however, that one of the participants in the previous experiments took *packed* to be a verb but read the target word *pack* as a noun. In such cases, what was meant to be an inflectionally related prime–target pair becomes a derivationally related pair. To the extent that this occurs, any differences between the (true) effects of inflected and derived primes would tend to be obscured.

Lexical ambiguity represents a potential problem not only for our Experiments 1 and 2, but also for all of the previous studies comparing inflected and derived primes in English (and perhaps for studies conducted in other languages as well). For example, Stanners et al. (1979) did not include a list of stimuli in their article but they give no indication that their stimuli were selected with lexical ambiguity in mind. Included among their example stimuli are *burn, shake,* and *lift,* each of which can be interpreted as either a noun or a verb. Similarly, Fowler et al. (1985) made no mention of lexical ambiguity in the description of their stimuli, and an examination of their stimulus list reveals a number of semantically ambiguous words (e.g., *yell, call, walk, talk,* and *roll*).

The stimuli in Experiments 3 and 4 were selected with this concern in mind. Given the high degree of ambiguity among English words, together with the other constraints on stimulus selection demanded by our design, it would be virtually impossible to construct a sufficiently large set of completely unambiguous items. Thus, we chose to use both unambiguous words and words that are strongly biased toward a specific interpretation. We used the ratings from a pilot study to select items for which both the base form and the inflected form are usually interpreted as verbs. (The suffixes of the derived primes made them unambiguous in relation to their targets). By selecting verbs as targets, we also excluded from the inflectional primes nominal plurals (e.g., *cats*), which are considered by some linguistics to be derivation-like inflections (e.g., Booij, 1993).

Another difference between the stimuli of Experiments 1 and 2 and the stimuli of Experiments 3 and 4 is that the target stimuli were lower in frequency in the latter experiments. The results of Experiment 2 suggested that any difference in the level of priming by inflections and derivations is very small. Because frequency is often inversely related to the magnitude of priming (e.g., Jacoby & Dallas, 1981; MacLeod, 1989; Scarborough, Cortese, & Scarborough, 1977), the use of lower frequency targets should enhance the sensitivity of our experiments, thus increasing the likelihood of finding any real, if small, gradations in the levels of morphological priming.

In most other respects, Experiments 3 and 4 mirrored Experiments 1 and 2. Thus, in Experiment 3 we investigated morphological priming using the fragment completion task; the lexical decision task was used in Experiment 4.

Method

Participants. Forty-five students participated in this experiment.

Design and materials. The design was similar to that of Experiment 1. Three types of primes (identity, inflection, and derivation) were studied in a semantically oriented study task and the base-form targets were subsequently tested in a word fragment completion task.

To ensure that both the targets and the inflected primes are usually read as verbs, the stimuli were selected on the basis of a paper-and-pencil pilot study given to a separate group of 20 students. A list of base-form words and their inflected forms was prepared for the pilot study on the basis of dictionary definitions. This list included a mix of items such that some words can be read only as verbs, some only as nouns, and some as either verbs or nouns. Participants rated each word on a scale from 1 to 7, where "1" was defined as "very strongly an action" and "7" as "very strongly a thing." There were two pilot lists: The first consisted of the base forms of half of the items and the inflected forms of the other half, and vice versa for the second list. The participants' attention was drawn to the fact that many English words can refer to an action (verb) or a thing (noun) when read out of context. The participants were instructed to base their judgments of the "stronger" meaning upon the first meaning that came to mind. Items that received a mean score lower than 2.5 for both the base and the inflected form and that did not receive more than one score higher than 5 were selected for the experimental list. Thus only when both the base form and its inflected form were reliably interpreted as verbs were they included in the experimental list.

A set of 48 word triplets were prepared for this experiment (see Appendix C), including five of the triplets from Experiments 1 and 2. As in the previous experiments, the word triplets included a base form, an inflected form, and a derived form (e.g., *believe, believed, believer*). The inflection suffixes included *-ed* (31), *-s* (10), and *-ing* (7). The derivational suffixes included *-er* (33), *-y* (5), *-or* (3), *-age* (2), *-ive* (2), *-ful* (2), and *-ure* (1). As in Experiments 1 and 2, inflected and derived primes were equated in terms of their orthographic similarity to the targets, and all were phonologically and semantically transparent. The base form targets were 3–9 letters long (mean 6) and had a mean frequency of 27 (median 12, range 1–200); the inflected primes had a mean of 7.7 letters and a mean frequency of 27 (median 14, range 0–172); and the derivational primes had a mean of 7.7 letters and a mean frequency of 18 (median 8, range 0–89) (Kucera & Francis, 1967). (After conducting the experiment we discovered that two items that failed to meet our criteria had been inadvertantly included in the experimental list. The triplets involving these items were excluded from the computation of the stimulus statistics described above, and the data from trials involving these triplets were discarded from the analyiss of the results.)

To prepare the test fragments, one or more (25–50%) letters of each of the target words were eliminated and replaced by an underlined blank (e.g., c_ew, a_v__ti_e). Approximately half the fragments had only one possible completion; the other half had several completions of which the target was not the highest in frequency. Thity-six filler words, 4–11 letters long (mean 7) with a mean frequency of 22 (median 10, range 2–106), were prepared for the study task. The fillers included a mix of nouns and adjectives, some of which had inflectional and derivational suffixes similar to those of the experimental primes. The 15 filler fragments from Experiment 1 were used for the filler task. The stimulus presentation and the counterbalancing were the same as in Experiment 1.

Procedure. The procedure was identical to that of Experiment 1, except that participants performed a slightly different semantic task during the study phase. In the present experiment, participants were asked to decide whether or not the presented word was a verb. This task was chosen because it seemed to be easier than the task used in Experiment 1. Seventy-two words were presented in the study task (36 primes and 36 fillers), 15 filler fragments were presented in the filler task, and 48 fragments were presented in the test task.

Results and Discussion

The target completion rates in the different priming conditions are shown in Table 1. The proportion of target completions varied as a function of priming condition and was highest in the identity priming condition, followed by the inflection, derivation, and unprimed conditions in that order. An ANOVA revealed that the effect of priming condition was significant by both subjects [$F_1(3,44) = 21.93$, $MSe = .02$, $p < .0001$] and items [$F_2(3,45) = 22.28$, $MSe = .02$, $p < .0001$]. A series of t tests showed that all three priming effects were significant by both subjects and items: for identity priming [$t_1(43) = 6.79$, $p < .0001$; $t_2(45) = 7.59$, $p < .0001$], for inflection priming [$t_1(43) = 6.03$, $p < .0001$; $t_2(45) = 5.11$, $p < .0001$], and for derivation priming [$t_1(43) = 5.42$, $p < .0001$; $t_2(45) = 7.02$, $p < .0001$]. The target completion rate was higher in the identity priming condition than in either the inflection priming condition [$t_1(43) = 2.60$, $p < .05$; $t_2(45) = 2.52$, $p < .05$] or the derivation priming condition [$t_1(43) = 2.60$, $p < .05$; $t_2(45) = 2.52$, $p < .05$]. The completion rates in the inflection and derivation conditions did not differ from one another [$t_1(43) = .12$, $p = .91$; $t_2(45) = .06$, $p = .95$], indicating that priming did not vary as a function of the morphological relation between the prime and the target.

Thus, using the fragment completion task and a new set of stimuli, we replicated the main results found in the two previous experiments. Again, inflections and derivations produced equivalent levels of morphological priming. This equivalence was observed even though the stimuli were selected to minimize the compromising effect of lexical ambiguity, and the targets were lower in frequency than those in Experiments 1 and 2. Yet the difference between the levels of priming by inflections and derivations did not increase and in fact was numerically slightly smaller. Thus the results of Experiment 3 suggest that inflections and derivations do not offer in their effectiveness as primes and that this null effect is not due to a lack of experimental sensitivity.

EXPERIMENT 4

In Experiment 4 we compared the effects of inflected and derived primes using the stimulus set of Experiment 3 and the lexical decision task used in Experiment 2.

Method

Participants. Fifty-one students participated in this experiment.

Materials and procedure. The same 48 word triplets from Experiment 3 were used in Experiment 4. As in Experiment 2, primes and targets were presented in a continuous list and participants performed the lexical decision task. Eight filler triplets were added in order to be able to use the list orders from Experiment 2. In addition to the 56 word triplets, a new set of 56 pseudo-word triplets was constructed for Experiment 4 such that the pseudo-words resembled the words in length and type of suffixes. (The pseudoword triplets are listed in Appendix D). In all other respects, Experiment 4 was identical in materials to Experiment 3 and in procedure to Experiment 2.

Results and Discussion

Incorrect responses and responses that were slower than 2000 ms or faster than 200 ms were excluded from the analysis of response times. Outliers accounted for less than 0.3% of all responses and the overall mean error rate was 2.75%. The data from one participant were discarded because of a high error rate (37%). In addition, as in Experiment 3, the data from two items were excluded from the analyses.

Response times. The mean response times for the different priming conditions are shown in Table 2. Response times varied as a function of priming condition and were fastest in the identity priming condition, followed by the derivation, inflection, and unprimed conditions in that order. An ANOVA revealed that the effect of priming condition was significant by both subjects [$F_1(3,50) = 13.21$, $MSe = 1317.00$, $p < .0001$] and items [$F_2(3,45) = 12.38$, $MSe = 1552.74$, $p < .0001$]. All three priming effects were significant, again by both subjects and items: for identity priming [$t_1(50) = 7.04$, $p < .0001$; $t_2(45) = 5.91$, $p < .0001$], for inflection priming [$t_1(50) = 2.62$, $p < .05$; $t_2(45) = 2.85$, $p < .01$], and for derivation priming [$t_1(50) = 3.76$, $p < .001$; $t_2(45) = 3.51$, $p < .001$]. Response times in the identity priming condition were significantly faster than in the inflection priming condition [$t_1(50) = 3.18$, $p < .01$; $t_2(45) = 3.15$, $p < .01$] and significantly faster than in the derivation priming condition [$t_1(50) = 2.26$, $p < .01$; $t_2(45) = 2.39$, $p < .05$]. Once again, reponse times in the inflection and derviation conditions were not significantly different from one another [$t_1(50) = .94$, $p = .35$; $t_2(45) = .98$, $p = .33$].

Error rates. The mean error rates for the different priming conditions are shown in Table 2. The pattern of errors resembled that of the response times. That is, the error rate varied as a function of priming condition and was lowest in the identity priming condition, followed by the derivation, inflection, and unprimed conditions in that order. An ANOVA revealed that the effect of priming condition was significant by both subjects ($F_1(3,50) = 13.35$, $MSe = .001$, $p < .0001$] and items [$F_2(3,45) = 9.68$, $MSe = .002$, $p < .0001$]. All three priming effects were significant by both subjects and items: for identity priming [$t_1(50) = 5.90$, $p < .0001$; $t_2(45) = 4.46$, $p < .0001$], for inflection priming [$t_1(50) = 4.56$ $p < .0001$; $t_2(45) = 2.96$, $p < .01$], and for derivation priming [$t_1(50) = 3.97$, $p < .001$; $t_2(45) = 3.46$, $p < .01$]. Although the error rate was numerically smaller in the identity priming condition than in either of the morphological priming conditions, the difference from the inflection priming condition was significant by subjects [$t_1(50) = 2.41$, $p < .05$] but not by items [$t_2(45) = 1.81$, $p = .077$], and the difference from the derivation priming condition was not significant in either analysis [$t_1(50) = 1.21$, $p = .23$; $t_2(45) = 1.27$, $p = 21$]. Finally, the error rates in the inflection and derivation priming conditions were not significantly different from one another [$t_1(50) = .46$, $p = .65$; $t_2(45) = .52$, $p = .61$].

The results of this experiment converge with those of the three previous experiments. As in the previous experiments, both inflections and derivations primed their targets. Not only was performance in the inflection and derivation priming conditions statistically equivalent, but both morphological priming effects were statistically smaller than the effect of identity priming. Thus, although some ambiguity arose concerning the lexical decision results of Experiment 2, the results of Experiment 4 are unequivocal: In the present experiment inflected and derived words were equally effective primes.

GENERAL DISCUSSION

Previous studies comparing the effectiveness of inflected and derived primes have produced mixed results. Inflections produced more priming than derivations in some studies (Fowler et al., 1985, Experiment 1; Stanners et al., 1979), but not in others (e.g., Fowler et al., 1985, Experiment 2; Napps, 1989). The main goal of the present study was to reexamine the contrast between inflected and derived primes in experimental circumstances that improve on those of the previous studies. In the present experiments the orthographic similarity of the primes and targets was strictly controlled and the inflected and derived primes were paired with the same target words, ensuring that the targets in the inflected and derived conditions were equated on all relevant factors. Under these conditions, English inflected and derived primes were consistently found to have equivalent effects. This pattern of results was observed across different priming tasks and different sets of stimuli. Specifically, inflections and derivations equally primed their base-form targets in both the fragment completion task (Experiments 1 and 3) and the lexical decision task (Experiments 2 and 4). This pattern of effects was obtained with two sets of stimuli that differ in several respects. In Experiments 3 and 4, the targets were lower in frequency and less ambiguous in their relation to the morphological primes than the targets used in Experiments 1 and 2. Despite these differences, the four experiments showed the same basic pattern of results.

Although we repeatedly found that inflected and derived primes had equivalent effects, a strong claim based on a null effect should always be made with caution. One aspect of the results of Experiment 2 suggests that there may be some difference in the levels of priming by inflections and derivations. Although a direct comparison of performance in the inflection and derivation priming conditions of Experiment 2 indicated that inflected and derived primes had equivalent effects, an indirect comparison supported an alternative conclusion. In particular, whereas priming in the inflection condition was statistically full relative to the identity priming condition, derived primes had a smaller effect than identity primes. Considered in isolation, this comparison suggests that inflected words are more effective primes than are derived words. However, our other findings, including in particular the analogous results from Experiment 4, point to the opposite conclusion. The latter results are especially noteworthy given that the materials for that experiment were chosen so as to increase the likelihood of detecting any difference between the effects of inflected and derived primes. This consideration, together with the results of the other experiments (including the direct comparison of inflected and derived primes in Experiment 2), makes it safe to conclude that, if there is a difference in the effectiveness of inflected and derived primes, it is a small difference that generally has little effect on performance.

What are the implications of the results for theories of the processing of morphologically complex words? Some proposals hold that different mechanisms are involved in the recognition of inflectional and derivational formations (Stanners et al., 1979; Taft, 1985, 1994) and predict different priming effects for the two types of words. In our experiments, however, inflections and derivations were equally effective primes, providing no support for the claim that different classes of morphologically complex words are processed in different ways.

Our results are in better agreement with models of morphological processing that hold that factors other than linguistic category per se determine how a word is identified (Chialant & Caramazza, 1995; Frauenfelder & Schreuder, 1992; Schreuder & Baayen, 1995). For example, some "dual-route" accounts hold that although a whole-word route is available for the identification of morphologically complex words, words that are orthographically and phonologically transparent (i.e., that preserve the spelling and pronunciation of the base word) are more likely to be identified via their morphemic constituents because these constituents can be exhaustively and unambiguously segmented (e.g., Burani & Laudanna, 1992; Chialant & Caramazza, 1995; Laudanna & Burani, 1995). The inflected and derived words in this study were all orthographically and phonologically transparent (in order to satisfy the control of orthographic similarity to the target). Thus, it is possible that both forms were identified via morphological decomposition.

Another proposed influence on the relative likelihood of recognition via morphological decomposition or lexical look-up is the frequency of the complex form. According to some dual-route models, the more often a word has been encountered, the more efficiently it is processed by the whole-word route and the more likely it is to be identified via this route. Conversely, the whole-word route is relatively slow at identifying low-frequency words, and thus these words are likely to be identified via morphological decomposition (e.g., Baayen, Dijkstra, & Schreuder, 1997; Baayen, Burani, & Schreuder, 1996; Burani & Laudanna, 1992; Frauenfelder & Schreuder, 1992; Schreuder & Baayen, 1995).[1] On this account, because both the in-

[1] There is some disagreement among dual-route models with respect to the role of frequency in determining the processing route for a certain subset of inflected words.

flected and the derived primes in our study were relatively low in frequency, both types of words were identified via morphological decomposition. The two types of words thus gave rise to equivalent priming effects.

Our results do not ensure that inflections and derivations will *never* differ in their effectiveness as primes. Inflections and derivations differ on a number of dimensions (see Introduction), and it is conceivable that these dimensions are among the factors that control how a given morphologically complex word will be identified and, hence, how it gives rise to priming. However, our results indicate that the syntactic and semantic differences between inflections and derivations are not *sufficient* to produce a difference in the manner in which these classes of words are processed. At least in the case of visual word recognition, lexical processes do not appear to be organized around morphological categories per se. If further research shows that in some circumstances (e.g., with high-frequency primes) inflections and derivations do give rise to priming effects of different magnitudes, the account of those results cannot be in terms of linguistic categories. Instead, a more fine-grained analysis couched in terms of the interaction of a variety of statistical and structural variables will be required.

We conclude by considering our results in light of the characteristics of the long-term priming methodology that we used to compare the processing of inflections and derivations. Although long-term priming measures are sensitive to manipulations related to the visual and orthographic properties of a word, they are largely insensitive to manipulations related to word meaning (for reviews, see Roediger & McDermott, 1993; Schacter, 1992; and Tenpenny, 1995). For example, priming between semantically or associatively related words (e.g., *doctor–nurse*) typically disappears or is considerably reduced when the prime and target are separated by several intervening items (e.g., Henderson, Wallis, & Knight, 1984; Dannenbring & Briand, 1982). Similarly, levels-of-processing manipulations typically have little effect on long-term priming (e.g., Jacoby & Dallas, 1981; for reviews, see Challis & Brodbeck, 1992, and Roediger & McDermott, 1993).

The relative ineffectiveness of semantic manipulations on long-term priming, together with the fact that inflected and derived words differ considerably in their semantic relationships to their base forms, raises the possibility that differences in the processing of inflections and derivations might be observed using methods that are more sensitive to semantic manipulations. The results of several recent studies investigating the effects of semantic transparency are consistent with this conjecture. In particular, although semantically transparent (e.g., *creation*) and semantically opaque (e.g., *creature*) derivations have been found to produce equivalent levels of long-term morphological priming (Bentin & Feldman, 1990; Feldman & Stotko, unpublished results, cited in Stolz & Feldman, 1995), semantically transparent primes have had a larger effect in experiments investigating short-term (i.e., SOA less than 1 s and no intervening items) priming (Bentin & Feldman, 1990; Marslen-Wilson, Tyler, Waksler, & Older, 1994).

Given these considerations, it will be important to extend the present research by determining whether inflections and derivations show different effects in paradigms that are sensitive to semantic processes. Such paradigms include short-term priming in the lexical decision task (e.g., Bentin & Feldman, 1990; see Neely, 1991, for a review) and long-term priming in the category exemplar generation task (e.g., Srinivas & Roediger, 1990; Vaidya, Gabrieli,

Whereas Burani and Laudanna (1992) claimed that frequency affects the processing of all inflections, Schreuder and Baayen (1995) claimed that frequency interacts with the semantic transparency of the inflected word. Specifically, when the meaning of an inflected word can be computed from the meaning of its constituents in a simple and straightforward way, the processing system does not develop a representation of the full form. Thus the processing of such fully transparent inflections would invariably be carried out by the parsing route, regardless of the word's frequency. In contrast, when some degree of semantic complexity is involved, as in the case of plural nouns, a lexical representation of the full-form is created, and the relative importance of this full-form representation in the recognition process is increased as a function of the frequency of that word.

Keane, Monti, Gutierrez, & Zarella, et al., 1997). Revealing in what circumstances (if any) the semantic differences between inflections and derivations have consequences for behavior would place important constraints on theories of visual word recognition.

APPENDIX A

The Target Words, Inflections, and Derivations from Experiments 1 and 2 and the Test Fragments from Experiment 1

bake, baked, baker, _ake; bind, binding, bindery, bi_d; block, blocking, blockage, __ock; boil, boiled, boiler, _oil; brain, brains, brainy, __ain; brew, brewing, brewery, _rew; camp, camped, camper, _amp; carry, carried, carrier, __rry; chat, chatting, chattery, _hat; cheer, cheers, cheery, ch_e_; cook, cooking, cookery, coo_; curl, curls, curly, cur_; fail, failing, failure, _ail; fill, filled, filler, fil_; hair, hairs, hairy, _air; harp, harping, harpist, har_; head, heads, heady, _ead; heat, heated, heater, _eat; home, homes, homey, ho_e; hunt, hunted, hunter, _unt; jump, jumps, jumpy, _ump; leak, leaking, leakage, lea_; link, linking, linkage, _ink; love, loved, lover, _ove; mood, moods, moody, moo_; need, needs, needy, _eed; nurse, nursing, nursery, __rse; own, owned, owner, ow_; pack, packed, packer, p_ck; paint, painted, painter, p_int; pass, passing, passage, _ass; play, played, player, pla_; post, posting, postage, _ost; risk, risks, risky, ris_; rob, robbed, robber, _ob; rock, rocks, rocky, _ock; room, rooms, roomy, _oom; sand, sands, sandy, _and; scan, scanned, scanner, sca_; sin, sinned, sinner, _in; sleep, sleeps, sleepy, s_eep; slip, slipping, slippery, _lip; snow, snows, snowy, s_ow; store, storing, storage, _to_e; storm, storms, stormy, st__m; sum, summing, summary, _um; tack, tacks, tacky, ta_k; test, tested, tester, _est; tour, touring, tourist, _our; trick, tricking, trickery, __ick; vote, voted, voter, _ote; walk, walked, walker, _alk; wash, washed, washer, wa__; will, willing, willful, wi__; wood, woods, woody, woo_; work, worked, worker, wor_.

APPENDIX B

The Target Pseudowords, Pseudoinflections, and Pseudoderivations from Experiment 2

barm, barmed, barmer; bim, bimmed, bimmer; binch, binching, binchery; bint, binting, bintage; blick, blicking, blickage; boak, boaking, boakage; bove, boved, bover; brab, brabed, braber; caft, cafts, cafty; chirt, chirts, chirty; cint, cints, cinty; cloe, cloing, cloage; crat, crats, craty; drave, draving, dravery; drine, drines, driney; fant, fants, fanty; feap, feaped, feaper; foad, foads, foady; fote, foted, foter; garge, garged, garger; geal, gealing, gealery; gowl, gowled, gowler; grig, griged, griger; gub, gubbed, gubber; kint, kints, kinty; loak, loaked, loaker; loce, loced, locer; lort, lorting, lortist; meaf, meafing, meafery; mirt, mirting, mirtage; moce, mocing, mocery; moze, mozed, mozer; nage, nages, nager; nuck, nucking, nuckery; pach, pached, pacher; pige, piges, pigey; plaw, plawing, plawery; pon, ponned, ponner; porth, porthing, porthage; rause, raused, rauser; rean, reans, reany; rofe, rofed, rofer; roop, roops, roopy; slar, slars, slary; slimp, slimps, slimpy; sork, sorking, sorkery; stug, stugs, stugy; tard, tarding, tardery; tolt, tolts, tolty; toop, tooped, tooper; tound, tounding, toundful; tud, tudding, tuddery; vait, vaits, vaity; wace, waced, wacer; walm, walms, walmy; woll, wolling, wollery.

APPENDIX C

The Target Words, Inflections, and Derivations from Experiments 3 and 4 and the Test Fragments from Experiment 3

advertise, advertised, advertiser, a_v__ti_e; announce, announced, announcer, _nno_n_e; arrange, arranged, arranger, _r_a_ge; assemble, assembling, assemblage, _s_em__e; bake, bakes, baker, ba_e; beg, begged, beggar, _eg; believe, believed, believer, _el__ve; broil, broiled, broiler, b_o_l; catch, catches, catcher, _atch; chew, chews, chewy, c_ew; compute, computed, computer, _o_pu_e; consume, consumed, consumer, co_s_m_; defend, defended, defender, _efe_d; deliver, delivers, delivery, _eli__r; destroy, destroyed, destroyer, _es_ro_; discover, discovers, discovery, d___ov_r; edit, edited, editor, e_it; elect, electing, elective, el__t; employ, employed, employer, _mp_o_; erase, erased, eraser, __ase; examine, examined, examiner, _xa__ne; fail, failing, failure, f_il; flatter, flatters, flattery, _lat__r; follow, followed, follower, _ol_ow; govern, governed, governor, go_e_n; heal, healed, healer, hea_; hunt, hunted, hunter, h_nt; impress, impressing, impressive, i_p_e_s; inquire, inquired, inquirer, i_q_i_e; interpret, interpreted, interpreter, __te__ret; jump, jumps, jumpy, _ump; listen, listened, listener, l__t_n; observe, observed, observer, _bs_r_e; pray, prayed, prayer, p_ay; publish, published, publisher, pu___sh; receive, received, receiver, _ec_i_e; recruit, recruited, recruiter, r_c__it; remind, reminded, reminder, _emi_d; resent, resenting, resentful, _es_nt; shrink, shrinking, shrinkage, s_ri_k; suffer, suffered, sufferer, _u_f_r; teach, teaches, teacher, _each; thank, thanking, thankful, t__nk; travel, traveled, traveler, tr__el; wash, washes, washer, was_; write, writes, writer, w__te.

APPENDIX D

The Target Pseudowords, Pseudoinflections, and Pseudoderivations from Experiment 4

adjolt, adjolted, adjolter; agorate, agorated, agorator; barm, barmed, barmer; bint, binting, bintage; blick, blicking, blickage; boak, boaking, boakage; bove, boved, bover; brab, brabed, braber; caft, cafts, cafty; chirt, chirts, chirty; conderm, condermed, condermor; crat, crats, craty; destrime, destrimes, destrimer; detrief, detriefing, detriefage; disarrow, disarrowing, disarrowful; drine, drines, driney; edunate, edunated, edunator; emglace, emglaced, emglacer; enrode, enroded, enroder; exepute, exeputed, exeputer; faunt, faunts, faunty; feap, feaped, feaper; fonble, fonbled, fonbler; gallover, gallovers, gallovery; garge, garged, garger; gark, garked, garker; geal, gealing, gealery; grig, griged, griger; gub, gubbed, gubber; immelse, immelsing, immelsive; impent, impented, impenter; incrodune, incroduned, incorduner; loak, loaked, loaker; meaf, meafing, meafery; nage, nages, nager; ostain, ostained, ostainer; patify, patified, patifier; pon, ponned, ponner; precrieve, precrieves, precriever; projure, projured, projurer; promuce, promuced, promucer; rause, raused, rauser; reanize, reanized, reanizer; regorve, regorved, regorver; relain, relaining, relainful; renogale, renogaled, renogaler; rumkle, rumkled, rumkler; sebure, sebured, seburer; seruce, seruces, serucer; slimp, slimps, slimpy; suflet, sufletted, sufletter; sursibe, sursibed, sursiber; throd, throds, thrody; trunch, trunching, trunchful; tud, tudding, tuddery; wanper, wanpered, wanperer.

REFERENCES

Anderson, S. R. (1982). Where's morphology? *Linguistic Inquiry,* **13,** 571–612.

Aronoff, M. (1976). *Word formation in generative grammar.* Cambridge, MA: MIT Press.

Baayen, R. H., Burani, C., & Schreuder, R. (1996). Effects of semantic markedness in the processing of regular nominal singulars and plurals in Italian. In G. E. Booij & J. van Marle (Eds.), *Yearbook of morphology 1996* (pp. 13–33). Dordrecht: Kluwer.

Baayen, R. H., Dijkstra, T., & Schreuder, R. (1997). Singulars and plurals in Dutch: Evidence for a parallel dual route model. *Journal of Memory and Language,* **37,** 94–117.

Bentin, S., & Feldman, L. B. (1990). The contribution of morphological and semantic relatedness to repetition priming at short and long lags: Evidence from Hebrew. *Quarterly Journal of Experimental Psychology,* **42A,** 693–711.

Bentin, S., & Frost, R. (1995). Morphological factors in visual word identification in Hebrew. In L. B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 109–129). Hillsdale, NJ: Erlbaum.

Booij, G. E. (1993). Against split morphology. In G. E. Booij & J. van Marle (Eds.), *Yearbook of morphology 1993* (pp. 27–50). Dordrecht: Kluwer.

Burani, C., & Laudanna, A. (1992). Units of representation for derived words in the lexicon. In R. Frost & L. Katz (Eds.), *Advances in psychology: Orthography, phonology, morphology and meaning* (pp. 27–44). Amsterdam: Elsevier.

Challis, B. H., & Brodbeck, D. R. (1992). Level of processing affecting priming in word fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* **18,** 595–607.

Chialant, D., & Caramazza, A. (1995). Where is morphology and how is it processed? The case of written word recognition. In L. B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 109–129). Hillsdale, NJ: Erlbaum.

Dannenbring, G. L., & Briand, K. (1982). Semantic priming and the word repetition effect in a lexical decision task. *Canadian Journal of Psychology,* **36,** 435–444.

Feldman, L. B. (1991). The contribution of morphology to word recognition. *Psychological Research,* **53,** 33–41.

Feldman, L. B. (1994). Beyond orthography and phonology: Differences between inflections and derivations. *Journal of Memory and Language,* **33,** 442–470.

Feldman, L. B., & Bentin, S. (1994). Morphological analysis of disrupted morphemes: Evidence from Hebrew. *Quarterly Journal of Experimental Psychology,* **47A,** 407–435.

Feldman, L. B., & Fowler, C. A. (1987). The inflected noun system in Serbo-Croatian: Lexical representation of morphological structure. *Memory & Cognition,* **15,** 1–12.

Feldman, L. B., & Moskovljevic, J. (1987). Repetition priming is not purely episodic in origin. *Journal of Experimental Psychology: Learning, Memory and Cognition,* **13,** 573–581.

Fowler, C. A., Napps, S. E., & Feldman, L. B. (1985). Relations among regular and irregular morphologically related words in the lexicon as revealed by repetition priming. *Memory & Cognition,* **13,** 241–255.

Frauenfelder, U. H., & Schreuder, R. (1992). Constraining psychological models of morphological processing and representation: The role of productivity. In G. E. Booij & J. van Marle (Eds.), *Yearbook of morphology 1991* (pp. 165–183). Dordrecht: Kluwer.

Garrett, M. (1980). Levels of processing in sentence production. In B. Butterworth (Ed.), *Language production* (Vol. 1, pp. 177–210). London: Academic Press.

Henderson, L. (1985). Towards a psychology of morphemes. In A. W. Ellis (Ed.), *Progress in the psychology of language* (Vol. 1, pp. 15–72). London: Erlbaum.

Henderson, L., Wallis, J., & Knight, D. (1984). Morphemic structure and lexical access. In H. Bouma & D. Bouhuis (Eds.), *Attention & performance X* (pp. 211–226). Hillsdale, NJ: Erlbaum.

Jackendoff, R. S. (1975). Morphological and semantic regularities in the lexicon. *Language,* **51,** 639–671.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General,* **110,** 306–340.

Kucera, H., & Francis, W. (1967). *Computational analysis of present-day American English.* Providence, RI: Brown Univ. Press.

Laudanna, A., & Burani, C. (1995). Distributional properties of derivational affixes: Implications for processing. In L. B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 345–364). Hillsdale, NJ: Erlbaum.

MacLeod, C. M. (1989). Word context during initial exposure influences degree of priming in word fragment completion. *Journal of Experimental Psychology: Learning, Memory and Cognition,* **15,** 398–406.

Marslen-Wilson, W., Tyler, L. K., Waksler, R., & Older, L.

(1994). Morphology and meaning in the English mental lexicon. *Psychological Review,* **101,** 3–33.

Miceli, G., & Caramazza, A. (1988). Dissociation of inflectional and derivational morphology. *Brain and Language,* **35,** 24–65.

Murrell, G. A., & Morton, J. (1974). Word recognition and morphemic structure. *Journal of Experimental Psychology,* **102,** 963–968.

Napps, S. E. (1989). Morphemic relationships in the lexicon: Are they distinct from semantic and formal relationships? *Memory & Cognition,* **17,** 729–739.

Neely, J. H. (1991). Semantic priming effects in visual word recognition. A selective review of current findings and theories. In D. Besner & G. Humphreys (Eds.), *Basic processes in reading: Visual word recognition.* (pp. 264–336). Hillsdale, NJ: Erlbaum.

Perlmutter, D. M. (1988). The split morphology hypothesis: Evidence from Yiddish. In M. Hammond & M. Noonan (Eds.), *Theoretical morphology* (pp. 79–100). San Diego: Academic Press.

Pinker, S. (1991). Rules of language. *Science,* **153,** 530–535.

Pinker, S., & Prince, A. (1991). Regular and irregular morphology and the psychological status of rules of grammar. Proceedings of the 1991 meeting of the Berkeley Linguistics Society.

Roediger, H. L., & McDermott, K. B. (1993). Implicit memory in normal human subject. In H. Spinnler & F. Boller (Eds.), *Handbook of neuropsychology* (vol. 8, pp. 63–130). Amsterdam: Elsevier.

Rueckl, J. G., Mikolinski, M., Raveh, M., Miner, C. S., & Mars, F. (1997). Morphological priming, fragment completion, and connectionist networks. *Journal of Memory and Language,* **36,** 382–405.

Sandra, D. (1994). The morphology of the mental lexicon: Internal word structure viewed from a psycholinguistic perspective. *Language and Cognitive Processes,* **9,** 227–269.

Scarborough, D. L., Cortese, C., & Scarborough, H. S. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance,* **3,** 1–17.

Schacter, D. L. (1992). Priming and multiple memory systems: Perceptual mechanisms of implicit memory. *Journal of Cognitive Neuroscience,* **4,** 244–256.

Schreuder, R., & Baayen, R. H. (1995). Modeling morphological processing. In L. B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 131–156). Hillsdale, NJ: Erlbaum.

Smith, P. T., & Sterling, C. M. (1982). Factors affecting the perceived morphemic structure of written words. *Journal of Verbal Learning and Verbal Behavior,* **21,** 704–721.

Srinivas, K., & Roediger, H. L. (1990). Classifying implicit memory tests on category association and anagram solution. *Journal of Memory and Language,* **29,** 389–412.

Stanners, R. F., Neiser, J. J., Hernon, W. P., & Hall, R. (1979). Memory representation for morphologically related words. *Journal of Verbal Learning and Verbal Behavior,* **18,** 399–412.

Stolz, J. A., & Feldman, L. B. (1995). The role of orthographic and semantic transparency of the base morpheme in morphological processing. In L. B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 109–129). Hillsdale, NJ: Erlbaum.

Taft, M. (1985). The decoding of words in lexical access: A review of the morphographic approach. In D. Besner, T. G. Waller, & G. E. MacKinnon (Eds.), *Reading research: Advances in theory and practice* (Vol. V, pp. 197–217). New York: Academic Press.

Taft, M. (1994). Interactive-activation as a framework for understanding morphological processing. *Language and Cognitive Processes,* **9,** 271–294.

Taft, M., & Forster, K. I. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior,* **14,** 638–647.

Tenpenny, P. L. (1995). Abstractionist vs. episodic theories of repetition priming and word identification. *Psychonomic Bulletin & Review,* **2,** 339–363.

Vaidya, C., Gabrieli, J. D. E., Keane, M. M., Monti, L. A., Gutierrez, R. H., & Zarella, M. M. (1997). Evidence for multiple mechanisms of conceptual priming on implicit memory tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* **6,** 1324–1343.

Weldon, M. S. (1991). Mechanisms underlying priming on perceptual tasks. *Journal of Experimental Psychology: Learning, Memory and Cognition,* **17,** 526–541.

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