Sublexical Components in Implicit Memory for Novel Words

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Five experiments investigated the role of sublexical components in implicit memory for novel words. Priming on an implicit word judgment task occurred consistently for nonwords formed out of familiar linguistic components (morphemes and syllables) but minimally for nonwords formed out of unfamiliar pseudoyllabic components. This effect was dissociable from explicit memory and insensitive to changes in the surface features of the stimuli. Moreover, it depended on unitization of stimulus components as opposed to priming of individual components. Results are interpreted in terms of the activation and integration of prior linguistic knowledge and as evidence against the role of new (perceptual or episodic) representations in implicit memory for new information.

There is growing consensus for the existence of two forms of memory: explicit memory and implicit memory. Explicit memory refers to the conscious or deliberate recollection of a prior event. Implicit memory, by contrast, refers to a change in task performance attributable to some prior event, often in the absence of conscious recollection of that event (for reviews, see Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993; Schacter, 1987). Performance changes on implicit memory tests are often known as priming effects. Explicit and implicit memory are dissociable in at least two senses: First, experimental variables such as depth of processing at the time of study (e.g., Graf & Mandler, 1984; Graf, Mandler, & Haden, 1982; Jacoby & Dallas, 1981) or a shift in modality of presentation between study and test (e.g., Jacoby & Dallas, 1981; Roediger & Blaxton, 1987) can affect one form of memory without also affecting the other; and, second, patients (e.g., Cermak, Taibot, Chandler, & Wolbarst, 1985; Graf, Squire, & Mandler, 1984; Moscovitch, 1982; Warrington & Weiskrantz, 1970) and subjects (Kihlstrom, 1980) with amnesia can show implicit memory in the absence of explicit memory.

Although the explicit–implicit distinction is fairly well accepted, the nature of implicit memory is subject to considerable debate. According to the activation view of priming, implicit memory represents the automatic activation, in the course of perception, of preexisting memory representations (e.g., Diamond & Rozin, 1984; Graf et al., 1984; Graf & Mandler, 1984; Morton, 1979). However, there is now considerable evidence of implicit memory for novel materials that do not have a preexisting memory representation; for example, nonwords (e.g., Feustel, Shiffrin, & Salasoo, 1983; Gordon, 1988; Musen & Squire, 1991; Rueckl, 1990; Scarborough, Cortese, & Scarborough, 1977; M. Smith & Oscar-Berman, 1990), novel pairings of unrelated words (e.g., Graf & Schacter, 1985, 1987; Moscovitch, Winocur, & McLachlan, 1986; Schacter & Graf, 1986), unfamiliar nonfamous names (e.g., Jacoby, Kelley, Brown, & Jasechko, 1989; Jacoby, Woloshyn, & Kelley, 1989; Neely & Payne, 1983; Squire & McKeel, 1992), and unfamiliar objects (e.g., Schacter, Cooper, & Delaney, 1990; Schacter, Cooper, Delaney, Peterson, & Tharan, 1991) and melodies (e.g., Johnson, Kim, & Risse, 1985). It has been suggested that effects of this kind, and implicit memory effects more generally, depend on the establishment of new representations in either episodic memory (e.g., Graf & Schacter, 1987; Jacoby, Woloshyn, et al., 1989; Schacter & Graf, 1986) or some domain-specific perceptual representation system (cf. Schacter, 1990; Tulving & Schacter, 1990). This may be called the new representations view of priming.

Although it is probably true that implicit memory for novel events cannot be understood in terms of the activation of inflexible units such as logogens (Morton, 1969, 1979), this objection does not hold for distributed models of mental representation. Consider, for example, Mandler's (1979, 1980) dual-process model of memory. According to this view, encoding invokes two processes, activation-integration and elaboration. Activation-integration is an automatic process that operates on prior probabilities of feature co-occurrence. The relevant units may be well-bounded structures already established in memory or structures that are in the process of being formed as a function of consistent inputs. Presentation of a familiar stimulus activates the constituent features of the representation of that item, which provides mutual activation and integration of those features. This renders the representation more cohesive and distinct, and easier to access on a subsequent test of implicit memory than the representations of items that did not receive such activation and integration. When an event is novel, componential units may be activated and integrated with other componential units activated at the same time, resulting in a cohesive and distinct representation.
of the perceived event. When an event is entirely novel (i.e., has no componential units already available in memory), a new representation of that event is laid down, as featural regularities are established in response to experiences with that event (see Mandler, Nakamura, & Van Zandt, 1987).

In contrast to activation–integration, elaboration is an effortful process that activates previously established relationships among memory structures, and, more important, establishes new ones. Elaboration is important for explicit memory because it allows the system to connect and recover trace information in response to retrieval cues. Activation–integration is important for implicit memory as it facilitates access to underlying representations on a wide variety of cognitive tasks. The two processes together are important for recognition memory. Although recognition is a form of explicit memory, according to the dual-process model it involves an implicit activation-based (familiarity) component in addition to an explicit elaboration-based (retrieval) component (see also Atkinson & Juola, 1973, 1974).

In choosing between the activation and new representations views of priming, it should be recognized that few, if any, events are entirely unfamiliar, and that perception is usually mediated by connecting representations of stimulus inputs to prior knowledge stored in memory, as in the case of pattern recognition. Thus, memory for novel events may be affected by the activation and integration of previously stored componential information. Certainly, componential information of this sort plays an important role in a variety of cognitive domains. For example, the perception of individual letters depends on memory for a small set of orthographic features (horizontal and vertical lines, acute angles, etc.), whereas the perception and recognition of words depends on a finite set of morphological, syllabic, and other sublexical structures (e.g., Spoehr & Smith, 1973; Taft & Forster, 1975, 1976; Treiman & Chavetz, 1987); components such as “geons” influence the perception and recognition of visual objects (e.g., Biederman, 1987; Hochberg & Peterson, 1987); and perceptual grouping and segmentation affect auditory pattern perception (e.g., Handel, 1973; Royer & Garner, 1970). Thus, there are reasons to think that implicit memory for ostensibly novel events might be produced by the activation of componential information already available in memory rather than the creation of entirely new representations.

Consider the case of words. There is now substantial evidence that morphological information is important in the production and perception of language. Thus, shifts or exchanges of morphemes occur in speech errors (e.g., Garrett, 1980), and morphological decomposition takes place in visual (and perhaps auditory) word recognition (e.g., Caramazza, Laudanna, & Romani, 1988; Fowler, Napps, & Feldman, 1985; Jarvella & Mejers, 1983; Murrell & Morton, 1974; Rapp, 1992; Stanners, Neiser, Hernon, & Hall, 1979; Taft & Forster, 1975). Findings such as these suggest that morphological information may be accessed and represented independently of whole-word information (see, for example, Caramazza et al., 1988; Fowler et al., 1985; Rapp, 1992; Taft & Forster, 1975). In this regard, perhaps novel words such as SUBVADE are encoded by automatically activating their component morphemes (e.g., SUB and VADE) and linking them to form an integrated representation.

In principle, a similar argument can be made with respect to syllables, although there is less convincing evidence that syllabic information is represented in memory—if for no other reason than that no clear definition of a syllable exists (cf. Hansen & Rodgers, 1968; Hoard, 1971; Kahn, 1980). Despite this, syllables are related to regularities in patterns of speech errors (e.g., MacKay, 1972) and serve as units in spoken word perception (e.g., Savin & Bever, 1970). Moreover, there is some evidence to suggest that syllabic information is important in visual word recognition (e.g., Eriksen, Pollack, & Montague, 1970; Klapp, 1971; Prinzmetal, Treiman, & Rho, 1986; Rapp, 1992; Spoehr & Smith, 1973; Taft & Forster, 1976; Taylor, Miller, & Juola, 1977; but see Barron & Pittenger, 1974; Forster & Chambers, 1973; Frederiksen & Kroll, 1976; Henderson, Cotheart, & Woodhouse, 1973; Seidenberg, 1987). Finally, a recent study on implicit memory has demonstrated an effect, under certain conditions, of syllabic information on a word-fragment completion test (Srinivas, Roediger, & Rajaram, 1992, Experiment 2). Evidence such as this, although not unequivocal, suggests that syllabic information may be extracted during language processing and have discrete representations in memory (see Rapp, 1992; E. Smith & Spoehr, 1974; Spoehr & Smith, 1973; Taft & Forster, 1976). Thus, a novel word such as BALBER may be processed through activation and integration of its nonmorphemic syllabic components (e.g., BAL and BER).

Before describing my research on the role of sublexical components in implicit memory for novel words, I briefly review previous findings of nonword priming. Note that a number of studies have failed to find evidence of nonword priming. For example, using the lexical decision task in which subjects are asked to decide whether or not a letter string is an English word, Forbach, Stanners, and Hochaus (1974) found priming for previously presented words but not for nonwords. In addition, several studies, though finding nonword priming in a variety of tasks in normal subjects, failed to find a similar effect in patients with amnesia for whom priming cannot be attributed to explicit memory factors (e.g., Cermak et al., 1985; M. Smith & Oscar-Berman, 1990). Despite these negative findings, there is increasing evidence for the existence of nonword priming. Much of this evidence comes from studies using the lexical decision task. (Null results obtained with this task are likely due to the inherent confounding of yes–no response and lexicality for nonword stimuli; see Feustel et al., 1983.) A subset of these studies has shown that previously exposed nonwords are classified more slowly and less accurately as nonwords, that is, they become more wordlike (e.g., Duchek & Neely, 1989; McKoon & Ratcliff, 1979; Neely & Durgunoglu, 1985); these effects are usually obtained when the prime is studied in a prior processing task unrelated to the lexical decision task. A second subset of studies has found a facilitatory effect for lexical decisions of nonwords; namely, that previously presented items are classified more quickly and accurately as nonwords (e.g., Besner & Swan, 1982; Dannenbring & Briand, 1982; Scarborough et al., 1977). These effects are generally obtained when the prime is presented earlier in the test list or when the prior processing task is also a lexical decision task. A facilitatory effect has also been obtained (albeit under limited conditions) when the
The implicit test used to assess priming was a word judgment task, subjects are given a stimulus item (or pair of items) and asked to judge it on some dimension (e.g., likeability, brightness, famousness). As in Zajonc's paradigm, the general finding is that subjects are biased in favor of items that were exposed previously. The effects of exposure are nonspecific and may be attributed to the mapping of the underlying activation of a representation to any stimulus-relevant judgment, for example, prior presentation of a novel shape facilitates judgments of brightness and darkness to the same extent (Mandler et al., 1987).

In the present study, subjects were presented with one previously exposed item (e.g., GENVIVE) and one new item (e.g., GENICLE) and asked to select which was a better English word. According to the activation-integration view, prior exposure of the nonword GENVIVE activates the morphemic components GEN and VIVE and integrates them into a cohesive, accessible unit. On the subsequent implicit word judgment task, subjects are biased to select the previously exposed item over an item with a different ending (CULE) that has not been so integrated with GEN. (Of course, theoretically activation of the second component alone could underlie priming given the composition of the stimulus items; this possibility is addressed, and refuted, in Experiment 5.) Priming was expected for nonwords formed out of morphemes and, perhaps, syllables. Minimal priming was expected for nonwords formed out of pseudosyllables, to the extent that such items should not activate discrete linguistic structures (aside from possibly activating familiar letter sequences or sound patterns).

The predictions of the activation-integration model contrast with those of the new representations view. According to that approach, initial presentation of a novel stimulus produces a new, highly specific representation of the features of that item in episodic memory or in the domain-specific word form system. Priming reflects the recapitulation of the processing operations engaged during study, and, for the typical data-driven or perceptual implicit test, is sensitive to the specific information available in the stimulus. Thus, regardless of the componential structure of a novel item, the features of the test stimulus match those of the newly established representation, meeting the requirement for priming. Accordingly, priming should be evident for pseudosyllabic nonwords in addition to nonwords formed from familiar sublexical components.  

Experiment 1

The primary purpose of Experiment 1 was to assess the effect of componential structure, morphemic or syllabic, on priming of nonwords formed out of constituents of existing words. Nonwords with morphemic structure were formed out

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1 Although it may be argued that the new representations view allows priming to be affected by preexisting representations, current formulations of the view make no clear predictions as to whether one should expect priming to differ based on the componential structure of a novel stimulus. Indeed, equivalent priming is often predicted for familiar and novel stimuli, including words and nonwords (e.g., Feustel et al., 1983; Rueckl & Olds, 1993), famous and nonfamous names (e.g., Jacoby, Woloshyn, et al., 1989), and so on.
of either two stems (e.g., GEN + VIVE, COM + FLECT), a prefix attached to a stem (e.g., OB + SIST, BE + MIT), or a suffix attached to a stem (e.g., LUX + FUL, PLEN + TRON). Nonwords with syllabic structure were formed out of two syllables (e.g., FAS + NEY, GAR + BRID); no distinctions were made among different types of syllabic structure. In view of evidence that morphemic information has discrete representations in memory, priming was predicted for nonwords with morphemic structure. Because the representational status of syllabic information is unclear, the question of priming for nonwords with syllabic structure was left open.

A second goal of Experiment 1 was to compare the effects of encoding activity (elaborative vs. nonelaborative processing) on priming and an explicit recognition test. It was predicted that type of processing would produce a differential effect on priming and recognition, with priming relatively invariant across processing conditions and recognition considerably better following elaborate than nonelaborative processing. Previous research has shown that implicit and explicit memory tests generally respond differentially to this variable (e.g., Graf & Mandler, 1984; Graf et al., 1982; Jacoby & Dallas, 1981). (Implicit tests with an elaborative or conceptually driven component, of course, may behave more similarly to explicit memory.) According to the present framework, priming is based primarily on the effects of activation-integration, which occurs automatically regardless of initial processing. Priming may exhibit some sensitivity to semantic variables, to the extent that elaborative processing enhances the effects of activation-integration; these effects are generally slight and often not statistically significant (Mandler, Hamson, & Dorfman, 1990; see also Challis & Brodbeck, 1992). The important point is that the magnitude of the difference across processing conditions should be considerably greater for the recognition task, in which conscious retrieval processes can contribute to test performance. Observing such a pattern of performance, then, would confirm that the word judgment task is tapping implicit, as opposed to explicit, memory (see, e.g., Schacter et al., 1990).

Of additional interest was the pattern of results for recogni-
tion following shallow processing. Under such test conditions, recognition is assumed to be based primarily on the effects of activation-integration, as opposed to the dual effects of activation-integration and elaboration (Mandler, 1980). Thus, the predictions for this condition were the same as for the word judgment task; namely, performance should be better than chance for nonwords formed from morphemes and possibly for nonwords formed from syllables.

Method

Subjects were presented with a list of nonwords and either counted the number of vowels in each item (shallow processing) or rated how much they liked each item (deep processing). On completion of the processing task, subjects were given either an implicit word judgment task, in which they were required to choose which of a pair of nonwords seemed like a better English word, or a forced-choice recognition memory test.

Subjects: Eighty undergraduates from the University of Arizona participated in the experiment for credit in an introductory psychology course. All subjects were native speakers of English and were tested individually.

Design. The general experimental design consisted of two between-subjects factors and one within-subjects factor. The between-subjects factors were type of processing (shallow vs. deep) and type of memory test (word judgment vs. recognition). The within-subjects factor was type of componential structure (morphemic vs. syllabic). Twenty subjects were randomly assigned to each experimental condition.

Materials: A pool of 126 word fragments was selected, half of which were morphemic fragments and half of which were syllabic fragments. The morphemic fragments were selected from comprehensive listings of stems and affixes (Byrne, 1987; Kennedy, 1971; Urdang, 1982, 1984), and the syllabic fragments were chosen from Merriam-Webster's College Dictionary (10th ed., 1993). The word fragments were matched for length across the two structural conditions. Word beginnings ranged in length from two to four letters, and word endings ranged from three to five letters. One third of the fragments for each structural condition served as word beginnings and two thirds served as word endings. Thus, there were 21 word beginnings and 42 word endings for each condition.

From this pool of word fragments, two matched lists of 21 nonword targets (List 1 and List 2) were constructed for each structural condition. Nonwords were formed by randomly pairing a word beginning with two equal length word endings. Thus, an example of a matched pair of nonwords is NEOPED, NEOGON. One of the items in each pair was assigned to List 1, and one was assigned to List 2. For the morphemic condition, this pairing procedure was performed to produce three kinds of items: items with stem-stem structure (e.g., CAL + TRUE, CAL + PRISE), items with prefix-stem structure (e.g., SUB + VADE, SUB + TAIN), and items with stem-suffix structure (e.g., LUX + FUL, LUX + OUS). Thus, there were seven pairs of items for each type of morphemic structure, for a total of 21 pairs of nonwords. All of the nonword pairs in the syllabic condition were of the same general structure, a syllabic beginning and a syllabic ending (e.g., BUR + PAIGN, BUR + LENGE).

For each processing condition, half the subjects received the target items from List 1 and half received the target items from List 2. The unpresented list served as distractors on the word judgment and recognition tests. Thus, each of the items in a pair was presented equally often as the target and the distractor. The targets and distractors were also counterbalanced across position on both the tests, such that each item was presented equally often on the left and the right.

Procedure. The procedure was identical for subjects in the word judgment and recognition conditions up until the time of test. On arrival in the laboratory, subjects were seated in front of a computer terminal and given instructions about the experiment. All subjects were given incidental learning instructions: They were told that the experiment was concerned with “how people process words” and were not informed that there would be a subsequent memory test. For all groups, 8 practice items were given to familiarize subjects with the procedure and to prevent primacy effects, and then the 42 study items were presented. Seven buffer items were presented to prevent recency effects. Each subject was given a different random arrangement of the stimulus items. Subjects in the shallow-processing condition were asked to count the number of vowels in each stimulus item. They were instructed to enter the number into the computer as quickly as possible and to pay attention only to the vowels. Subjects in the deep-processing condition were asked to rate how much they liked each item on a scale ranging from dislike very much (1) to like very much (7). Subjects were not given specific instructions on how to make their liking ratings and were allowed as much time as needed to give their responses. Speed of response was deliberately different for the two processing conditions; fast responses were emphasized for the shallow-processing group to minimize elaborate encoding but not for the deep-processing group in which elaborate encoding was desired.

After completing the processing task, subjects were given instruc-
tions about the memory task. Subjects in the word judgment condition were led to believe that they were participating in a different experiment for which they were providing normative data. They were told that the experiment was concerned with "people's knowledge of the structure of English words," and in particular, "people's initial gut feelings about which item in a pair seems like a better English word.

Subjects were given a pair of nonwords, one old and one new (e.g., CALTRUDE, CALPRISE), and asked to decide which one was a better English word. It was emphasized that they choose the item that "immediately strikes you as a 'better' English word," or that "stands out" as a better English word. If the item on the left was seen as better, subjects pressed the 4 key; if the item on the right was seen as better, subjects pressed the 8 key. Subjects were told to respond as quickly as possible and to give their first impression for each pair. Subjects in the recognition condition were given a pair of items and asked to choose which one they had seen when they were either counting vowels or making liking ratings, depending on their processing condition. As for the word judgment test, they were instructed to press the 4 key for the item on the left and the 8 key for the item on the right. Subjects were allowed as much time as needed to give their responses. Subjects in both test conditions received a different random arrangement of the test items.

Results

The word judgment and recognition data are summarized in Table 1. For each test condition, the table gives the mean proportion of correct responses for morphemic and syllabic items as a function of type of prior processing. For the word judgment task, this corresponds to the proportion of target items selected as better English words, and for the recognition task, to the proportion of hits. The analyses reported in this article were based on both subject (F1, t1) and item (F2, t2) variability. The means and standard deviations presented in the tables were taken from the subject analyses. A significance level of .05 was used unless otherwise stated. Any discrepancies between means may be attributed to rounding.

I first conducted a three-way (Test × Processing × Structure) analysis of variance (ANOVA). This analysis revealed a significant main effect of test, F1(1, 76) = 37.96, MSw = .020, F2(1, 40) = 116.83, MSw = .007, with performance better on the recognition test (.68) than on the word judgment test (.54). A significant main effect of processing was also found, F1(1, 76) = 15.88, MSw = .020, F2(1, 40) = 45.34, MSw = .007, with performance better following deep processing (.66) than following shallow processing (.57). There was some indication that depth of processing produced a differential effect on word judgments and recognition. The Test × Processing interaction was significant, F1(1, 76) = 8.87, MSw = .020, F2(1, 40) = 13.13, MSw = .015, with recognition performance considerably better following deep than shallow processing but word judgment performance relatively invariant across processing conditions. This effect, however, must be treated with caution because floor effects may have been operating in the word judgment condition. Neither the main effect of structure nor any of the other interactions approached significance (all Fs < 1.5).

Keeping in mind any possible floor effects, I now turn to the word judgment data. As shown in Table 1, all of the means were numerically greater than chance, but only those for the morphemic condition were statistically so. Following shallow processing, morphemic targets were selected at a rate of .55, in contrast to a chance rate of .50, for a priming effect of .05, t1(19) = 2.12, p < .05, t2(20) = 1.98, p < .05. Similarly, following deep processing, morphemic targets were selected at a rate of .57, yielding priming of .07, t1(19) = 2.02, p < .05, t2(20) = 3.02, p < .01. Syllabic targets, by contrast, were selected at a rate of .52 under shallow-processing conditions, yielding nonsignificant priming of .02, t1(19) = .82, t2(20) = .73. Under deep-processing conditions, they were selected at a rate of .54, yielding nonsignificant priming of .04, t1(19) = 1.14, t2(20) = 1.69. Overall performance did not differ significantly for morphemic and syllabic items, t3(38) = 1.13, t2(40) = 1.44.

An analysis of the morphemic data alone found some indication of an effect of specific structure. Across processing conditions, performance was numerically greater for items with stem-stem (.58) and prefix-stem (.59) structure than items with stem-suffix (.51) structure. The main effect of structure was marginally significant in an ANOVA by items, F2(2, 18) = 2.86, p = .083, MSe = .009, but did not reach significance in an ANOVA by subjects, F1(2, 76) = 1.69, p = .191, MSw = .043. The Structure × Processing interaction was not significant in either analysis (both Fs < 1). Comparing the means for each condition to chance, t tests showed significant priming for items with stem-stem structure, both by subjects, t1(39) = 2.16, p < .05, and by items, t2(6) = 2.28, p < .05. The effect for nonwords with prefix-stem structure reached significance in the analysis by subjects, t1(39) = 2.71, p < .01, but not in the analysis by items, t2(6) = 1.85. No priming was found for items with stem-suffix structure in either analysis, t1(39) = .34, t2(6) = .30.

Table 1 shows that recognition performance was above chance for both structural conditions. Following shallow processing, the proportion of hits was .61 for the morphemic condition, compared with a chance rate of .50, t1(19) = 4.63, p < .001, t2(20) = 5.22, p < .001. The hit rate for the syllabic condition was .60, t1(19) = 3.54, p < .001, t2(20) = 5.18, p < .001. Following deep processing, the proportions were considerably larger, .77 for the morphemic group, t1(19) = 10.04, p < .001, t2(20) = 15.11, p < .001, and .75 for the syllabic group, t1(19) = 8.81, p < .001, t2(20) = 12.23, p < .001. This depth of processing effect is similar to a previous finding by Mitterer and Begg (1979), showing better recognition for nonwords following judgments of meaningfulness than following judgments of pronounceability.

<table>
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<tr>
<th>Word Judgment and Recognition Data in Experiment 1</th>
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<td>Test and structural condition</td>
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<tr>
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Note: Proportion of targets correctly selected or recognized. Chance = .50.
*p < .05. **p < .01. ***p < .001.
Experiments 1 and 3

Word Judgment Data Classified by Baseline Preference in Experiments 1 and 3

<table>
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<td>Low</td>
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Note. Mean proportion correct (PC), baseline (Bas), and priming (Prm) for high-, medium-, and low-preference items. Dashes indicate data not applicable for measure.

A final analysis of the word judgment data was conducted to examine performance in terms of the baseline preference of the stimulus items (i.e., the proportion of the time an item is selected without prior presentation). Base rates were determined by testing an additional 20 subjects on the word judgment task without a prior processing task. Average preference values for each stimulus item were derived from the proportion of subjects who chose an item over its matched distractor. Thus, a score of .60 for the item GIMLOR indicates that 12 of 20 subjects preferred GIMLOR over the distractor GIMNAL. The scores for each item ranged from .10 to .90, with an average value of .50. The 24 highest and 24 lowest items were selected as high- and low-preference items, respectively, leaving 36 items of medium preference. The scores ranged from .10 to .35 for low-preference items, .40 to .60 for medium-preference items, and .65 to .90 for high-preference items.2 There were 14 morphemic and 10 syllabic low-preference items, 14 morphemic and 22 syllabic medium-preference items, and 14 morphemic and 10 syllabic high-preference items.

Table 2 shows the morphemic and syllabic data broken down by baseline preference; the data are collapsed across processing condition because no effect of processing was evident in the overall ANOVA. The first column gives the mean proportion of correct (PC) word judgments; the second column gives the baseline scores (Bas); and the third column shows the average of correct (PC) word judgments; the second column gives the proportion correct and baseline scores across subjects.

An ANOVA of the priming scores was conducted using the variables of componential structure (morphemic vs. syllabic), preference (low vs. medium vs. high), and stimulus list (List 1 vs. List 2). The variable of stimulus list was included in the analysis because low- and high-preference items necessarily came from the same stimulus pairs and, thus, were not entirely independent (e.g., if CALTRUDE was a low-preference item, then CALPRISE was necessarily a high-preference item). By including the variable of list in the analysis, one can observe the pattern of data for each set of materials separately. The analysis revealed a highly significant main effect of preference, $F(2, 76) = 32.14, MS_x = .029, F(2, 72) = 10.54, MS_x = .022$. Priming was evident for low-preference ($p = .15$) and medium-preference ($p = .07$) items but not for high-preference items ($p = .06$). A Newman-Keuls test on the subject data showed that all three of these values differed; a test on the item data showed that high-preference items differed from low- and medium-preference items, which did not differ from one another. The effect of preference did not interact with stimulus list in either analysis, $F(2, 76) = 1.37, p = .261, MS_x = .029, F(2, 72) = .34, p = .713, MS_x = .022$. There was a significant interaction of preference and structural condition in the analysis by subjects, $F(2, 76) = 5.47, MS_x = .026$, and a marginally significant interaction in the analysis by items, $F(2, 72) = 10.54, p = .084, MS_x = .022$. This effect appears to be due to the high-preference data for the syllabic group, which showed negative priming. The Preference × Structure × Stimulus List interaction did not reach significance (both $F_s < 1$). It should be noted that reliable priming of syllabic items was observed when high-preference items were excluded from the analysis. Subjects selected low- and medium-preference target items at a rate of .12, $t(19) = 2.66, p < .01$, $t(31) = 3.78, p < .001$, in contrast to the nonsignificant rate of .03 in the overall ANOVA. The results of the preference analysis, then, suggest that priming may occur for nonwords formed out of syllables in addition to nonwords formed out of morphemes.

It should be recognized, however, that a regression-to-the-mean artifact may have contributed to the positive and negative priming effects observed for low- and high-preference items, respectively. Thus, items with low-preference scores in the baseline condition may have regressed to the mean in the experimental condition, ostensibly showing a priming effect. Similarly, items with high-preference scores in the baseline condition may have regressed to the mean and become lower in the experimental condition, as appears to be the case for the syllabic condition. The fact that such an effect did not occur for high-preference items in the morphemic condition, however, argues against such an interpretation, as does the fact that priming was evident in both conditions for medium-preference items (where one would expect regression effects to cancel one another out). The role of a regression artifact was directly tested, and ruled out, in Experiments 3 and 4.

Experiment 2

Experiment 1 provided preliminary evidence of priming effects on a word judgment task that were dissociable from recognition memory. Priming was obtained for nonwords with morphemic structure, and under certain conditions (i.e., when the preference range of the stimulus items was restricted) for nonwords with syllabic structure. Overall, priming was greater

2 An analysis using a different breakdown scheme yielded a similar pattern of results. On this scheme, there were 21 low-preference items, ranging from .10 to .36; 42 medium-preference items, ranging from .35 to .65; and 21 high-preference items, ranging from .70 to .90.
for morphemic than for syllabic items; and within the morphemic condition, priming was greater for items with stem-stem and prefix-stem structure than for items with stem-suffix structure. Compared with the recognition task, the word judgment task was relatively insensitive to encoding activity; this dissociation supports the conclusion that priming on the word judgment task is, in fact, an expression of implicit memory. The finding of priming for nonwords formed out of familiar linguistic components is consistent with the notion that implicit memory for novel words depends on the activation and integration of prior linguistic knowledge. This contrasts with recognition for nonwords, which may be based on the effects of elaboration in addition to the effects of activation-integration. The fact that recognition under shallow-processing conditions yielded above-chance performance for morphemic and syllabic items provides further evidence that both kinds of information are represented in memory.

The results of Experiment 1 must be treated with caution, however, because of the possible operation of floor effects. In Experiment 2, I sought to replicate the effects of Experiment 1 using only items that are not ordinarily preferred by subjects, that is, items of low-to-medium baseline preference. Experiment 1 suggested that the magnitude of priming is greater for such items. One group of subjects completed a liking-judgment task followed by the implicit word judgment task, and another group completed a vowel-counting task. The recognition test was not included in the experiment.

Method

Subjects. An additional 40 students from the University of Arizona participated as subjects.

Design. The general experimental design consisted of one between-subjects factor (type of processing) and one within-subjects factor (type of componential structure). Twenty subjects were randomly assigned to each experimental condition.

Materials and procedure. The stimulus materials were adapted from those used in Experiment 1. Although all 42 pairs of nonwords were the same as those used in the first experiment, assignment to the target and distractor lists was changed. Low-preference items (i.e., baseline preference of .10 to .35) were always used as targets, whereas high-preference items (.65 to .90) were always used as distractors. Medium-preference items (.40 to .60) were used as either targets or distractors. This resulted in 7 medium-preference and 14 low-preference morphemic targets and 11 medium-preference and 10 low-preference syllabic targets, for a total of 42 items.

Subjects were presented with the list of 42 nonwords and asked to either count the number of vowels in each item (shallow processing) or rate how much they liked each item (deep processing). After completing the processing task, all subjects were given the implicit word judgment test for the 42 nonword pairs.

Results

The data are shown in Table 3. For each processing condition (PC), the first column gives the mean proportion of morphemic and syllabic targets chosen correctly; the second column gives the baseline proportion (Bas) correct, or the rate at which targets are selected without prior study; and the last column gives the priming scores (Prm), or the difference between the proportion correct and baseline scores across subjects. The baseline proportions in this experiment were calculated from the baseline preference data collected in Experiment 1.

I conducted an ANOVA of the priming scores using the variables of processing (shallow vs. deep) and componential structure (morphemic vs. syllabic). As expected, the main effect of processing was not significant, $F_{1}(1,38) = 0.02, M_{S} = .103, F_{2}(1,40) = .02, M_{S} = .010$, with priming not differing for the shallow (.10) and deep (.10) conditions. The main effect of componential structure was also not reliable, $F_{1}(1,38) = .73, M_{S} = .010, F_{2}(1,40) = .47, M_{S} = .040$. Priming did not differ for morphemic (.11) and syllabic (.09) items, suggesting that morphemic structure is no better than syllabic structure at promoting priming. The Processing $\times$ Structure interaction also failed to reach significance, $F_{1}(1,38) = .05, M_{S} = .010, F_{2}(1,40) = .12, M_{S} = .010$.

As shown in Table 3, $t$ tests confirmed that significant priming occurred for morphemic and syllabic items in both processing conditions. In the shallow-processing condition, morphemic targets were selected at a rate of .45, compared with a base rate of .34, for a priming effect of .11, $t_{38} = 3.20, p < .01, t_{20} = 4.61, p < .001$. Similarly, syllabic items were selected at a rate of .46, compared with a base rate of .38, for a priming effect of .08, $t_{38} = 2.82, p < .01, t_{20} = 2.47, p < .05$. In the deep-processing condition, morphemic targets were selected at a rate of .45, in contrast to a base rate of .34, for a priming effect of .11, $t_{38} = 3.94, p < .001, t_{20} = 3.91, p < .001$. Syllabic targets were chosen .47 of the time, compared with a base rate of .38, for a priming effect of .09, $t_{38} = 2.98, p < .01, t_{20} = 2.50, p < .05$.

An analysis of the morphemic data in terms of specific morphemic structure failed to reveal any effects. Although there was some indication that priming differed for items with stem-stem (.10), prefix-stem (.13), and stem-suffix (.08) structure, this difference did not reach significance in an ANOVA, $F_{1}(2,76) = 1.05, M_{S} = .033, F_{2}(2,18) = .28, M_{S} = .037$. The Structure $\times$ Processing interaction also did not achieve significance, $F_{1}(2,76) = .26, M_{S} = .033, F_{2}(2,18) = .11, M_{S} = .010$.

Experiment 3

Experiment 2 replicated the results of Experiment 1 using items that have low- or medium-baseline preference ratings. Priming was twice as great as in Experiment 1, eliminating the problem of potential floor effects. Priming was invariant across processing conditions, as one might expect if word judgments

### Table 3

Word Judgment Data in Experiment 2

<table>
<thead>
<tr>
<th>Structural condition</th>
<th>Shallow processing</th>
<th>Deep processing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PC</td>
<td>Bas</td>
</tr>
<tr>
<td>Morphemic</td>
<td>M</td>
<td>.45</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>.13</td>
</tr>
<tr>
<td>Syllabic</td>
<td>M</td>
<td>.46</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>.10</td>
</tr>
</tbody>
</table>

Note. PC = mean proportion correct; Bas = baseline; Prm = priming. Dashes indicate data not applicable for measure.

*p < .05. **p < .01. ***p < .001.
are tapping implicit memory. Overall, priming did not differ for morphemic and syllabic nonwords; moreover, priming was evident for morphemic nonwords with stem-suffix structure in addition to morphemic nonwords with stem-stem and prefix-stem structure. This pattern of results is consistent with the hypothesis that priming of novel words is mediated by preexisting representations of componential information; however, it is not definitive. This is because priming might be mediated by new representations of the global form of a stimulus laid down in episodic memory or in a perceptual representation system.

Accordingly, Experiment 3 compared priming of morphemic and syllabic nonwords with nonwords in which components are neither morphemic nor syllabic in nature—that is, with items in which components are unlikely to have preexisting representations in memory. These items may be called pseudosyllabic because they are formed from syllable-like components that do not participate in existing English words. Examples are ERKTOFE (neither ERK nor TOFE exist as morphemes or syllables in English) and HIRNPUSM (the same is true of HIRN and PUSM). Unlike morphemes and syllables, such components do not map precisely onto existing mental structures. At best, they activate familiar sequences of letters (e.g., the string ERK found in perk and clerk) or sound patterns (e.g., the pronunciations of OFE resembles the sound in oaf and loaf). Thus, if priming is mediated by activation and integration of sublexical components, little effect should be obtained with pseudosyllabic items. However, if priming is mediated by a newly formed episodic or perceptual representation, independent of componential structure, effects of similar magnitude should be found for all three types of items. Because Experiment 2 had confirmed that priming was invariant across shallow- and deep-processing conditions, the elaborate processing task was eliminated from the design of this and subsequent experiments.

A baseline condition was also run, in which a group of subjects completed the word judgment task without prior presentation of the stimulus items. Thus, unlike in Experiment 2 in which the preference scores (from Experiment 1) that served as a baseline to assess priming were also used to select the items, in this experiment a new sample of preference scores was used as a baseline to assess priming for already selected items. This eliminates the problem of a regression-to-the-mean artifact being responsible for any priming effects observed, at least for the morphemic and syllabic conditions (the role of a regression artifact in priming for pseudosyllabic items was tested in Experiment 4).

A final goal of Experiment 3 was to examine recognition memory for the three kinds of stimulus items. If recognition under nonelaborative processing conditions is primarily a function of activation–integration, as is held by dual-process theory, one should see a similar pattern of performance as on the word judgment test (i.e., better recognition for items with familiar sublexical components than for items with unfamiliar pseudosyllabic components).

### Method

**Subjects.** An additional 60 students from the University of Arizona participated as subjects.

**Design.** The experimental design consisted of one between-subjects variable (type of test: word judgment vs. recognition) and one within-subjects variable (type of componential structure: morphemic vs. syllabic vs. pseudosyllabic).

**Materials and procedure.** In addition to the set of items used in Experiments 1 and 2, 21 new pairs of nonwords were constructed. This entailed selecting a pool of fragments that existed as neither morphemes nor syllables in the English language. This constraint was tested by conducting a search for the fragment in the Kucera and Francis (1967) norms. Although the fragment could not exist as a syllable in English, it was permissible for it to exist as a letter string across syllable boundaries. Like the stimuli in the first two experiments, nonwords were formed by randomly pairing a word beginning (e.g., ERK) with two word endings matched for length (e.g., TOFE, FAND). The final two lists of nonwords were matched in length with the morphemic and syllabic items.

The assignment of the items to target and distractor lists differed for morphemic–syllabic and pseudosyllabic items. The morphemic-syllabic items were assigned in the same manner as in Experiment 2, that is, only low- and medium-preference items were used as targets. Because the effect of baseline preference had not yet been established for pseudosyllabic items, items of all preference values were included. Thus, half of the subjects received List 1 items as targets and List 2 items as distractors, and half received List 2 items as targets and List 1 items as distractors, similar to the procedure in Experiment 1. Direct comparison of low- and medium-range morphemic–syllabic and pseudosyllabic items was made in Experiment 4.

One group of subjects counted the number of vowels in each of the 63 stimulus items and then performed the implicit word judgment task for the 63 nonword pairs. A second group of subjects completed the vowel-counting task and then performed the explicit forced-choice recognition test for the 63 word pairs. A final control group completed the word judgment task without prior presentation of the stimulus items. This group was tested to compute baseline scores in the new stimulus environment. Twenty subjects were randomly assigned to each experimental condition, and 20 to the control condition.

### Results

For each test condition, Table 4 shows the mean proportion of correct responses (PC) for morphemic, syllabic, and pseudosyllabic items, the baseline proportion correct (Bas), and the difference between the proportion correct and baseline scores across subjects (Prm/Dif), which are priming scores in the case of the word judgment task and difference scores in the case of the recognition task. The baseline proportions were calculated from the control group data for the word judgment condition;
for the recognition condition, the baseline was always assumed to be chance (.50).

A 2 (word judgment vs. recognition) × 3 (morphemic vs. syllabic vs. pseudosyllabic) ANOVA was conducted on the priming and difference scores. This analysis yielded a significant main effect of componential structure by subjects, $F_3(2, 76) = 3.23$, $MS_e = .012$, and a marginally significant effect by items, $F_2(2, 60) = 2.45$, $p = .095$, $MS_e = .017$. A Newman-Keuls test by subjects showed that performance across tasks was lower for pseudosyllabic items (.05) than for morphemic (.11) and syllabic (.10) items, which did not differ from one another. A Newman-Keuls test by items showed that none of the means differed from one another. Neither the main effect of test nor the Test × Structure interaction reached significance (all Fs < 1).

As shown in Table 4, robust priming of word judgments was again evident for nonwords formed out of morphemic and syllabic components. Targets in the morphemic condition were selected at a rate of .43, in contrast to a baseline level of .33, yielding a priming effect of .11, $t_1(38) = 3.46, p < .01$, $t_2(20) = 3.22, p < .01$. Targets in the syllabic condition were selected at a rate of .50, in contrast to a baseline level of .40, for a priming effect of .10, $t_1(38) = 3.07, p < .01$, $t_2(20) = 3.24, p < .01$. The magnitude of priming is similar to that observed in Experiment 2, in which priming was .11 for morphemic items and .08 for syllabic items. This shows that the enhanced priming observed for low-preference items in Experiments 1 and 2 is unlikely to be an artifact of regression to the mean.

A small nonsignificant priming effect was found for nonwords formed out of pseudosyllabic components. Pseudosyllabic targets were selected at a rate of .55, in contrast to a baseline of .51, yielding a nonsignificant priming of .04, $t_1(38) = 1.59, t_2(20) = 1.61$. However, a one-tailed test comparing the proportion of correctly selected targets with chance (.50), as was done in Experiment 1 for morphemic and syllabic items, yielded significant priming, $t_1(19) = 2.30, p < .05$, $t_2(20) = 2.40, p < .05$. Moreover, despite the presence of a numerical advantage for morphemic and syllabic items over pseudosyllabic items, priming did not differ for the three kinds of items. The magnitude of priming for pseudosyllabic items is similar to what was observed for morphemic and syllabic items in the comparable (shallow processing) condition in Experiment 1, in which items of an unrestricted preference range were also used. In that experiment, priming effects of .05 and .02 were found for morphemic and syllabic items, respectively.

Although the word judgment data suggest that full-strength priming may occur for pseudosyllabic nonwords, further analyses compromise such an interpretation. Analysis of the pseudosyllabic data in terms of baseline preference failed to reveal enhanced priming for items with low- or medium-preference values, as has been observed consistently for morphemic and syllabic nonwords (see Experiments 1 and 2). Breakdowns were established according to baseline preference values obtained from the control group. There were 16 low-preference items ranging from .05 to .35, 10 medium-preference items ranging from .40 to .60, and 16 high-preference items ranging from .65 to .90. Table 2 shows that performance was no better for low-preference items (.06) and medium-preference items (.04) than for high-preference items (.04), $F_1(2, 36) = .14, MS_e = .019$, $F_3(2, 36) = .68, MS_e = .038$. This contrasts with the morphemic-syllabic data in Experiment 1, in which priming was .15 for low-preference items, .07 for medium-preference items, and -.06 for high-preference items. The foregoing analysis also provides further evidence against a regression-to-the-mean interpretation of priming. Had regression been operating, one should have seen heightened priming for low-preference items and negative priming for high-preference items, as was the case for morphemic-syllabic items in Experiment 1.

The recognition data showed a pattern of performance similar to that of the word judgment data. Morphemic targets were correctly recognized at a rate of .62, in contrast to a chance level of .50, yielding a difference score of .12, $t_1(19) = 3.03, p < .01$, $t_2(20) = 4.15, p < .001$. Syllabic targets were correctly recognized at a rate of .60, for a difference score of .10, $t_1(19) = 3.39, p < .001$, $t_2(20) = 2.88, p < .01$. This is similar to what was observed in the comparable shallow-processing condition of Experiment 1, in which the difference scores were .11 and .10 for the morphemic and syllabic conditions, respectively. Performance for pseudosyllabic items was numerically smaller than that for morphemic and syllabic items; the proportion of correct recognition responses was .56, yielding a difference score of .06. This rate, however, differed significantly from chance, $t_1(19) = 2.06, p < .05$, $t_2(20) = 2.74, p < .01$; this may be attributed to residual elaborative-retrieval effects that occurred in spite of the shallow-processing manipulation (Mandler et al., 1990).

It should be noted that orthographic frequency of the letters in the stimuli was not responsible for the observed differences between morphemic-syllabic and pseudosyllabic items on the word judgment and recognition tests. Although the average frequency of both bigrams and trigrams (Solso, Barbuto, & Juel, 1979) was greater for morphemic and syllabic than pseudosyllabic items, the factor of frequency had little influence on the extent of facilitation on either test. That is, high-frequency items were no more likely to be primed or recognized than low-frequency items.

Experiment 4

Experiment 3 obtained robust priming effects for both morphemic and syllabic nonwords but minimal priming for pseudosyllabic nonwords. This pattern of performance was also evident on a recognition memory test and, moreover, was not an artifact of orthographic properties of the stimulus items on either test. Finally, priming of morphemic and syllabic items could not be attributed to regression to the mean. These results are consistent with the notion that priming relies on the

3 According to the activation-integration view, low- and medium-preference morphemic-syllabic items benefit considerably from the activation and integration produced by prior presentation to the extent that they have relatively low baseline activation values. High-preference morphemic-syllabic items, however, are unlikely to benefit much from the effects of activation-integration because their resting activation levels are considerably higher (i.e., approaching asymptote). Pseudosyllabic items do not show such an effect because they have little in the way of preexisting representations to activate.
activation and integration of prior linguistic knowledge. Furthermore, they suggest that recognition following shallow processing also relies primarily on activated and integrated sublexical information.

At first glance, the similar pattern of performance on the word judgment and recognition tasks suggests that explicit memory may underlie the present effects. This is unlikely to be the case, however, given the clear absence of a depth-of-processing effect for the priming task in Experiments 1 and 2. Moreover, previous research has shown that subjects exhibit little or no explicit retention of verbal material following a vowel-counting manipulation (Mandler et al., 1990).

Table 5: Word Judgment Data in Experiment 4

<table>
<thead>
<tr>
<th>Case and structural condition</th>
<th>PC</th>
<th>Bas</th>
<th>Prm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same case</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Morphemic</td>
<td>.48</td>
<td>.14</td>
<td>.38</td>
</tr>
<tr>
<td>Syllabic</td>
<td>.49</td>
<td>.10</td>
<td>.41</td>
</tr>
<tr>
<td>Pseudosyllabic</td>
<td>.43</td>
<td>.10</td>
<td>.41</td>
</tr>
<tr>
<td>Different case</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Morphemic</td>
<td>.46</td>
<td>.11</td>
<td>.38</td>
</tr>
<tr>
<td>Syllabic</td>
<td>.46</td>
<td>.10</td>
<td>.41</td>
</tr>
<tr>
<td>Pseudosyllabic</td>
<td>.45</td>
<td>.08</td>
<td>.41</td>
</tr>
</tbody>
</table>

Note. PC = mean proportion correct; Bas = baseline; Prm = priming. Dashes indicate data not applicable for measure.

*p < .05. **p < .01. ***p < .001.

However, priming of pseudosyllabic nonwords is mediated by a new episodic or perceptual representation, it should be reduced even further by structural changes.

Method

Subjects. An additional 60 students from the University of Arizona served as subjects.

Materials and procedure. The set of stimulus items used in Experiment 3 was modified so that the items in each structural condition were equated according to baseline preference. To accomplish this, the pool of items was reduced from 21 nonword pairs per condition to 18 nonword pairs per condition.

Subjects in both case conditions were presented with the 54 stimulus items in upper case and asked to count the number of vowels in each item. One group of subjects then received the implicit word judgment test with the items switched to lower case, and another received the test with the items maintained in upper case. Subjects in the different-case condition were not informed of any change in the appearance of the items. Subjects in the control condition performed the word judgment task without prior presentation of the study list. Twenty subjects were randomly assigned to each case condition and 20 were randomly assigned to the control condition.

Results

The proportion of correct word judgments, baseline proportion correct, and priming scores for each case condition are shown in Table 5. An ANOVA of the priming scores was conducted using the factors of case (same vs. different) and componential structure (morphemic vs. syllabic vs. pseudosyllabic). As expected, priming was no greater for the same-case condition (.07) than the different-case condition (.06), the main effect of case, $F(1, 38) = .26, MS_e = .012, F(1, 51) = .18, MS_e = .013$. This is consistent with previous findings showing little effect of case shifts on priming (e.g., Feustel et al., 1983; Scarborough et al., 1977; but see, e.g., Roediger & Blaxton, 1987, for evidence of reduced priming following typescript changes). The main effect of componential structure was marginally significant in the analysis by subjects, $F(2, 76) = 2.99, p = .056, MS_e = .010$, but nonsignificant in the analysis by items, $F(2, 51) = 1.08, MS_e = .028$. Across case conditions, priming was .08 for morphemic items, .07 for syllabic items, and .03 for pseudosyllabic items. The Case × Structure interaction was not reliable in either analysis. Combining the data with those from Experiment 3, a significant effect of componential structure was found by subjects, $F(2, 116) = 4.92, p < .01, MS_e = .011$, and a marginally significant effect was found by items, $F(2, 60) = 3.08, p = .053, MS_e = .019$. Across experiments, priming was higher for morphemic (.09) and syllabic (.08) nonwords than for pseudosyllabic (.03) nonwords. A Newman-Keuls test on the subject data confirmed that both morphemic and syllabic items differed from pseudosyllabic items but that the two did not differ from each other; none of the three item types differed in a test on the item data. In neither analysis did the effect of structure interact with experiment ($F$s < 1).

Table 5 shows that the proportion of morphemic and syllabic items correctly selected was significantly greater than the base rate in three of four cases. In the same-case condition, morphemic targets were selected at a rate of .48, in contrast to
a base rate of .38, for a priming effect of .09, \( t_1(38) = 2.50, p < .05, t_2(17) = 2.55, p < .05 \). Similarly, syllabic targets were selected at a rate of .49 (vs. .41) for the baseline condition, for a priming effect of .09, \( t_1(38) = 2.75, p < .01, t_2(17) = 3.15, p < .01 \). In the different-case condition, subjects chose morphemic targets .46 of the time, in contrast to a baseline level of .38, for a priming effect of .08, \( t_1(38) = 2.28, p < .05, t_2(17) = 2.17, p < .05 \). Syllabic items were selected at a rate of .46, in contrast to a baseline of .41, for nonsignificant priming of .05, \( t_1(38) = 1.64, t_2(17) = 1.26 \). Priming did not significantly differ, however, for morphemic and syllabic items, \( t_1(19) = .73, t_2(34) = .41 \).

Pseudosyllabic items, by contrast, failed to exhibit significant priming in either case condition. In the same-case condition, performance was not appreciably better for primed items (.43) than for the baseline group (.41), \( t_1(38) = .57, t_2(17) = .62 \). The different-case data showed performance of .45, in contrast to a .41 baseline, for nonsignificant priming of .04, \( t_1(38) = 1.22, t_2(17) = 1.35 \).

**Experiment 5**

Experiment 4 confirmed the basic finding of Experiment 3: greater priming for morphemic and syllabic nonwords than for pseudosyllabic nonwords. Contrary to the new representations view, priming of nonwords was unaffected by a shift in case. This was true for pseudosyllabic items in addition to morphemic–syllabic items, suggesting that whatever priming is observed for pseudosyllabic items depends on activation (e.g., of familiar letter clusters or sound patterns), as opposed to new, highly specific representations of the structural features of a stimulus.

Although the results of the first four experiments show conclusively that priming can occur for nonwords formed from morphemic and syllabic components, the precise mechanism mediating this effect remains uncertain. According to the activation–integration view, presentation of a morphemic or syllabic item activates preexisting representations of the individual morphemes or syllables and then integrates them to form a new word. However, it is possible that priming of such items is mediated by activation of only a single component. For example, if subjects study the morphemic nonword GENVIVE, only the individual components GEN and VIVE may be activated without any integration of the two elements. On a later test, then, subjects may be biased to prefer the target GENVIVE over the distractor GENCULE because the morpheme VIVE has been primed but the morpheme CULE has not.

To test this possibility, I constructed a new set of stimulus items in which the components were rearranged such that test items only partially matched the nonwords presented for study. In one condition, the right-hand components of the stimulus items were re-paired with left-hand components from other stimulus items. Thus, PILVIVE was the study item for the test pair GENVIVE–GENCULE, and GENDOM was the study item for the test pair PILDOM–PILCUR. Rearranged stimuli were used as study items as opposed to test items to ensure that test items were equated on baseline preference. Both arrangements should produce similar outcomes because in either case priming of a test item would be produced by presentation of the second component (e.g., VIVE) of the stimulus item. In a second condition, the left- and right-hand components of each two-component nonword were reversed, with VIVEGEN and DOMPIEL being the study items for the tests pairs GENVIVE–GENCULE and PILDOM–PILCUR, respectively. If activation of individual components is the sole mechanism of priming, then effects of similar magnitude should be observed for originals and rearrangements. However, if priming requires integration as well as activation, priming should be reduced or eliminated when the test items are rearrangements of the originals.

**Method**

**Subjects.** An additional 40 students from the University of Arizona served as subjects.

**Materials and procedure.** The transformed stimulus items were constructed as follows. For the re-paired condition, the right-hand component from each stimulus item was matched with the left-hand component from a different stimulus item. For example, the VIVE from GENVIVE was paired with the PIL from PILDOM, and the PAIGN from BURPAIGN was paired with the WIL from WILBARD. For the reversed items, the left- and right-hand components from each individual stimulus item were transposed, such that the right-hand component became the beginning of the word and the left-hand component became the end of the word (e.g., VIVEGEN, PAINGBURL). The procedure was identical to that used in the same-case condition in Experiment 4 except that subjects were given the rearranged stimulus items in the first phase of the experiment. They then were given the implicit word judgment task with the original 54 pairs of nonwords. Twenty subjects were randomly assigned to each transformation condition.

**Results**

The data are shown in Table 6. I first conducted an ANOVA using the factors of transformation and structure. The main effect of transformation was not significant, \( F_1(1, 38) = .20, MS_e = .019, F_2(1, 51) = .28, MS_e = .010 \), with priming no greater for the re-paired (.01) than the reversed (.00) condition. The main effect of structure was marginally significant in the analysis by subjects, \( F_1(2, 76) = 2.51, p < .088, MS_e = .009 \), but nonsignificant in the analysis by items, \( F_2(2, 51) = .91, MS_e = .025 \), with priming of .03 for morphemic items, .01 for syllabic items, and –.02 for pseudosyllabic items. The Transfor-
A summary of the word judgment data is shown in Table 7. Across the seven conditions in Experiments 1-4, there was a priming effect of .09 for morphemic items, .07 for syllabic items, and .03 for pseudosyllabic items. This pattern of data was evident in all the conditions that compared priming between morphemic—syllabic and pseudosyllabic items (Experiment 3; Experiment 4, same-case; Experiment 4, different case), as well as in the implicit (shallow-processing) recognition condition in Experiment 3 (see Table 4).

These results suggest that componential information plays some role in implicit memory effects, consistent with what has been observed in other cognitive domains. In word perception, subjects exhibit sensitivity to morphological, syllabic, and other sublexical structures (e.g., Caramazza et al., 1988; Fowler et al., 1985; Klapp, 1971; Murrell & Morton, 1974; Pring, 1981; Rapp, 1992; Santa, Santa, & Smith, 1977; Spoehr & Smith, 1973; Stanners et al., 1979; Taft & Forster, 1975, 1976; Treiman & Chavetz, 1987). Similarly, individual components such as geons have been found to influence the perception and recognition of visual objects (e.g., Biederman, 1987; Hochberg & Peterson, 1987), and there is evidence for perceptual grouping and segmentation in the processing of auditory patterns (e.g., Handel, 1973; Royer & Garner, 1970).

It is unlikely that the present effects relied on explicit memory. Experiment 1 showed that the variable of depth of processing, which generally affects explicit memory more than implicit memory (e.g., Graf & Mandler, 1984; Graf et al., 1982; Jacoby & Dallas, 1981), produced a differential effect on priming and an explicit recognition test. Experiment 2, moreover, confirmed that priming was invariant across shallow- and deep-processing conditions, and that the absence of a depth-of-processing effect was not due to floor effects. Finally, postexperimental interviews indicated that only several subjects showed explicit awareness of the connection between the study and test phases; that is that test items had been previously exposed in the vocabulary-counting or liking-judgment tasks.

The finding of an advantage for nonwords formed out of linguistic units suggests that priming relies on contact with

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**Table 7**

Summary of Word Judgment Data in Experiments 1-5

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<th>Structural condition</th>
<th>1sh</th>
<th>1dp</th>
<th>2sh</th>
<th>2dp</th>
<th>3</th>
<th>4sm</th>
<th>4df</th>
<th>M</th>
<th>5rp</th>
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<td>.07*</td>
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<td>.11***</td>
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<td>.08*</td>
<td>.09</td>
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<td>.02</td>
<td>.02</td>
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<tr>
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<td>.08**</td>
<td>.09**</td>
<td>.10**</td>
<td>.09**</td>
<td>.05</td>
<td>.07</td>
<td>.02</td>
<td>.01</td>
<td>.01</td>
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<tr>
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<td></td>
<td>.04</td>
<td></td>
<td>.02</td>
<td></td>
<td>.03</td>
<td></td>
<td>.02</td>
</tr>
</tbody>
</table>

Note: Mean proportion priming for morphemic, syllabic, and pseudosyllabic items. 1sh = Experiment 1, shallow processing; 1dp = Experiment 1, deep processing; 2sh = Experiment 2, shallow processing; 2dp = Experiment 2, deep processing; 3 = Experiment 3; 4sm = Experiment 4, same-case; 4df = Experiment 4, different-case; 5rp = Experiment 5, re-paired; 5rv = Experiment 5, reversed. Dashes indicate data not available for measure.

*p < .05. **p < .01. ***p < .001.

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A summary of the word judgment data is shown in Table 7. Across the seven conditions in Experiments 1-4, there was a priming effect of .09 for morphemic items, .07 for syllabic items, and .03 for pseudosyllabic items. This pattern of data was evident in all the conditions that compared priming between morphemic—syllabic and pseudosyllabic items (Experiment 3; Experiment 4, same-case; Experiment 4, different case), as well as in the implicit (shallow-processing) recognition condition in Experiment 3 (see Table 4).4

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The finding of an advantage for nonwords formed out of linguistic units suggests that priming relies on contact with

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4 According to the dual-process model, recognition under shallow-processing conditions is based on an implicit activation-based component, similar to priming. Under deep-processing conditions, recognition is based on both activation (familiarity) and elaboration (conscious retrieval).
knowledge that is already available in memory. This is inconsistent with the notion that implicit memory effects, for new information or otherwise, rely on newly established representations in either episodic memory (e.g., Jacoby, 1983; Roediger & Blaxton, 1987) or a domain-specific perceptual system (e.g., Schacter, 1990; Tulving & Schacter, 1990). The present findings are more readily accounted for in terms of the activation and integration of preexisting knowledge (cf. Mandler, 1979, 1980, 1989).

According to the activation-integration view, priming of ostensibly novel information is due to the activation and subsequent integration of whatever components of a stimulus are available in memory. In the present paradigm, initial processing of a nonword activates familiar sublexical components and integrates those components into a cohesive unit containing relational and serial-directional links. Thus, the nonword GENVIVE activates and integrates the morphemic components GEN (found in genus, general, gender, etc.) and VIVE (found in survive, revive, vivify, etc.), and the nonword FASNEY activates and integrates the syllabic components FAS (found in fasten, fascinate, fascist, etc) and NEY (found in chimney, kidney, journey, etc.). The activation and integration of the sublexical components, and consequent distinctiveness of the integrated representation, may then be related to any judgment that is stimulus relevant (Mandler et al., 1987); in this case, a judgment as to which of a pair of items (e.g., GENVIVE, GENCRULE) is a better English word. The fact that priming occurred for morphemic nonwords with prefix-stem (e.g., OBIST, BEMIT) and stem-suffix (e.g., LUXFUL, PLENTRON) structure in addition to items with stem-stem structure (e.g., GENVIVE, COMFLECT) suggests that stem and affix information alike are subject to the effects of activation-integration. The smaller effect for stem-suffix items, however, indicates that suffix information may be less easily integrated.

If an item's components are not already available in memory, then there is minimal opportunity for activation and integration to take place. Thus, a truly novel stimulus, such as an "impossible" object that has no familiar subcomponents (see Schacter et al., 1990), or a novel melody composed of a random sequence of tones, should activate little in the way of preexisting memorial information. The pseudosyllabic nonwords in the present study (e.g., ERKTOFE, HIRNPUSM), although not completely novel (i.e., they are composed of familiar letters), do not activate discrete sublexical components that can easily be integrated. Indeed, the largest units that a pseudosyllabic item may activate are familiar letter clusters (e.g., ERK, found in perk and clerk) or sound patterns (e.g., OF, found in oaf and loaf). Although such activation effects may be responsible for the finding of nonzero priming for pseudosyllabic items, they are unlikely to produce strong, consistent priming of the kind observed for nonwords formed from distinct sublexical components.

Experiment 5 confirmed that priming of morphemic and syllabic nonwords relies on the integration or unitization of stimulus components, as opposed to activation of individual components. Indeed, there was no evidence of priming when the components making up a stimulus item were either re-paired with components from another item (e.g., PILVIVE as a prime for the test item GENVIVE; GENDOM as a prime for PILDOM) or reversed (e.g., VIVEGEN as a prime for GENVIVE; DOMPIL as a prime for PILDOM). The right portion of Table 7 shows that across the two conditions of Experiment 5, nonsignificant priming was found for morphemic items (.03), syllabic items (.01), and pseudosyllabic items (.02). These results suggest that priming is not mediated by activation of the second constituent of an item but by a connected, integrated representation of the two constituents. This idea is analogous to Biederman's (e.g., Biederman & Cooper, 1991) notion that priming of visual objects relies on a representation of components in specified relations. Further research is needed, however, to clarify the relative role of activation and unitization in priming of morphemic and syllabic nonwords.

Additional evidence that supports the role of activation and integration in priming of word judgments is the finding that priming remains intact despite changes in specific surface information (Experiment 4). This is inconsistent with the new representations account of implicit memory, which attributes priming to a newly established representation of word shape that is sensitive to specific surface information. The failure to find such a result, together with similar negative findings in previous studies (e.g., Feustel et al., 1983; Scarborough et al., 1977), suggests that priming relies on a relatively abstract code developed from previous experience with linguistic information. The fact that the small priming effect for pseudosyllabic items was not reduced by a shift in case, moreover, provides further evidence for the notion that priming of pseudosyllabic items relies on residual activation effects, as opposed to a newly established episodic or perceptual representation.

The finding of priming for items with familiar sublexical components, together with the failure to find an effect of surface features, is consistent with a previous proposal by Weldon (1991). Briefly, she argues that multiple processes, including lexical access, perceptual or surface processing, and conceptual processing, contribute to implicit test performance, depending on the specific encoding conditions and implicit test under consideration. Moreover, access to lexical information may be a precondition for priming; as in the present view, this information may include not only word-level units but any abstract, higher order unit. Given that lexical access has occurred, the physical similarity between the prime and the target may contribute to the magnitude of priming. Conceptual processing contributes to priming to the extent that a particular task is sensitive to semantic variables (akin to the role of elaborative processing on the present view). Although Weldon acknowledges that sublexical units may be represented in the lexicon, her account does not specify which units might be the relevant ones, and the role of sublexical information is not central to her reasoning. Nevertheless, her theory bears some similarities to the present approach and may be seen as an
alternative way of conceptualizing the effects of sublexical structure on priming.

It also remains possible that a modified new representations account could accommodate the present findings. In contrast to existing formulations, such an account would need to allow for the effects of prior knowledge, specifying precisely when preexisting representations contribute to priming. It could be argued, for example, that a new representation is more easily established when an incoming stimulus is composed of familiar units. The more perceptually salient are the incoming units, the more likely the stimulus is to be represented in a stable form. Abstract effects, such as a change in case or other visual features, may be explained by allowing the system access to abstract letter codes, or by arguing that a particular feature is not relevant to the processing operations carried out on a stimulus. However, findings of cross-modality word priming, particularly those that do not rely on imaginal or episodic factors (see, e.g., Graf, Shimamura, & Squire, 1985), are difficult to reconcile with a view that attributes priming to newly established representations within a modular perceptual representation system, or within episodic memory. The perceptual representations view of priming needs to provide a more satisfying explanation of how individual perceptual representation systems interact with one another and with other (e.g., semantic and episodic) memory systems. Similarly, the episodic approach needs to provide a principled account of when a particular feature is relevant to processing.

Implications for Explanations of Implicit Memory for New Information

Although other researchers have claimed that evidence of priming of novel materials necessitates a new representations account of priming (e.g., Jacoby, Woloshyn, et al., 1989; Musen & Squire, 1991; Schacter et al., 1990), the foregoing discussion suggests that such a conclusion may be premature. Indeed, novel stimuli such as nonwords, pairs of unrelated words, and unfamiliar names and objects may be broken down into familiar subcomponents, be they individual letters, words, or geons. This suggests that priming of new information may rely on the activation of preexisting representations of componential information, as opposed to newly established representations independent of prior knowledge.

Consistent with this notion, previous findings of nonword priming (e.g., Feustel et al., 1983; Gordon, 1988; Musen & Squire, 1991; Rueckl, 1990; Scarborough et al., 1977; M. Smith & Oscar-Berman, 1990) have generally been obtained with pronounceable, orthographically legal stimulus items. Such stimuli are likely to make contact with preexisting linguistic representations. Thus, priming of the nonword MURE may result from activation of the familiar letter sequence URE, or from excitatory effects on the letter nodes M, U, R, and E produced by activation of words such as MORE, MUSE, and CURE (McClelland & Rumelhart, 1981), whereas priming of the nonword ERBOW may be based on activation and subsequent integration of the syllabic components ER and BOW.

Activation of componential information may also play a role in implicit memory for pairs of unrelated words (e.g., Graf & Schacter, 1985, 1987; McKoon & Ratcliff, 1979; Moscovitch et al., 1986; Schacter & Graf, 1986). For example, priming of the word pair MOTHER–CALENDAR may be based on activation of the component words MOTHER and CALENDAR, and subsequent integration of those words into a cohesive structure (see Mandler, 1989). Consistent with such a view, stem completion for pairs of unrelated words relies on presentation of a test cue that accesses both components of a stimulus pair (e.g., MOTHER–CAL, as opposed to MOTHER– ; Graf & Schacter, 1985). Moreover, it has been shown that priming in a speeded reading task occurs for individual words within a pair in addition to the pair itself (Moscovitch et al., 1986).

A similar process may occur for implicit memory for unfamiliar, nonfamous names (e.g., Jacoby, Kelley, et al., 1988; Jacoby, Woloshyn, et al., 1989; Squire & McKee, 1992). Biased fame judgments for the name VALERIE MARSH, for example, may be based on activation of the familiar first name VALERIE or the familiar surname MARSH or on activation and integration of the two stimulus components. In agreement with the former notion, Squire and McKee (1992) have shown that priming of fame judgments is as great for recombined first and last names as for originals. This indicates that priming is not based on a newly established representation of a first and last name but simply on activation of an individual component; specifically, the last name (Neely & Payne, 1983). When a last name is potentially unfamiliar, as in the case of SEBASTIAN WEISDORF, priming may be based on activation of componential information within that name (e.g., WEIS, as in Weisel and Weisberg; DORF, as in Waldorf and Dusseldorf).

An activation view is also capable of accounting for findings of priming of novel nonverbal information. Thus, priming of unfamiliar three-dimensional objects (e.g., Schacter et al., 1990, 1991) may be based on activation of structural components of familiar objects such as cones, cylinders, spheres, and so forth (cf. Biederman, 1987), as opposed to establishment of new representations in a structural description system that represents global object form. Priming of novel shapes, melodies, and the like can be attributed to activation of familiar components such as line segments, melodic sequences, and so forth.

Implications for Theories of Word Recognition and Lexical Organization

The results of the present study also have implications for theories of word recognition and lexical organization. The fact that priming was observed for morphemic and syllabic nonwords alike indicates that both types of information are extracted when a word is presented visually. This is consistent with Taft's (cf. Taft, 1985) notion of morphographic processing, in which readers avail themselves of both morphological structure and orthographic syllable structure.

The finding of priming for nonwords formed out of morphemes and syllables is consistent with the results of a number of previous studies (e.g., Caramazza et al., 1988; Eriksen et al., 1974; Fowler et al., 1985; Klapp, 1971; Murrell & Morton, 1974; Prinzmetal et al., 1986; Rapp, 1992; Spoehr & Smith, 1973; Stanners et al., 1979; Taft & Forster, 1975, 1976; Taylor

SUBLEXICAL COMPONENTS
et al., 1977). For example, Murrell and Morton have shown that tachistoscopic recognition of words (e.g., BORING) is facilitated by prior presentation of morphological but not orthographic relatives (e.g., BORE vs. BORN; see also Fowler et al., 1985; Stanners et al., 1979). Similarly, Taft and Forster (1975, 1976) found that morphemic stems such as VIVE take longer to classify as nonwords than do pseudostems such as LISH, and that first syllables such as PLAT are classified more slowly as nonwords than letter strings such as PREN that are not first syllables.

There are a number of studies, however, that have failed to document syllabic effects (e.g., Barron & Pittenger, 1974; Forster & Chambers, 1973; Frederiksen & Kroll, 1976; Henderson et al., 1973; Seidenberg, 1987). This, taken together with the fact that there is little agreement over how to define a syllable (e.g., Hansen & Rodgers, 1968; Hoard, 1971; Kahn, 1980), suggests that syllabic information per se may not be extracted in the word recognition process. Rather, it may be that recovery of information correlated with syllables is responsible for putative syllabic effects. The present finding of priming for nonwords formed out of syllables, then, may not reflect the activation and integration of syllabic representations but processing of subsyllabic representations. The importance of subsyllabic information, indeed, is likely the explanation for my observation of nonzero priming for nonwords formed out of pseudosyllables.

The growing evidence for the importance of sublexical structures suggests that the lexicon is organized with obligatory representations of morphemes, syllables, and other units. Thus, word recognition may be achieved through access to sublexical "input" units that serve as an intermediary to whole-word representations (e.g., E. Smith & Spoehr, 1974; Spoehr & Smith, 1973; Taft & Forster, 1975, 1976). Similarly, a word may be recognized by means of excitatory and inhibitory activation spreading through a hierarchically organized network of letter-level, sublexical, and word-level nodes (e.g., Andrews, 1986; Fowler et al., 1985). On the other hand, sublexical structures may simply be activated as a byproduct of processing a word (e.g., Caramazza et al., 1988), or more extreme, may be an artifact of facts about the frequency and distribution of letter patterns (e.g., Seidenberg, 1987; Seidenberg & McClelland, 1989).

To conclude, the results of the present study show clearly that componential information plays a role in implicit memory, as it does in language processing, visual perception, and other cognitive domains. Priming of nonwords occurs consistently when items are formed out of familiar sublexical (morphemic and syllabic) components, but minimally when items are formed out of unfamiliar pseudosyllabic components. These results suggest a reinterpretation of previous findings of implicit memory for new information, which may reflect the activation and integration of preexisting representations of componential information as opposed to the establishment of new episodic or perceptual memory traces. Indeed, it is likely that we acquire new vocabulary words such as microchip, new word compounds such as compact disc, and new names such as Bill Clinton through the linkage and synthesis of incoming patterns with previous knowledge stored in memory.

References


Frederiksen, J. R., & Kroll, J. F. (1976). Spelling and sound:
SUBLEXICAL COMPONENTS

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SUBLEXICAL COMPONENTS

Appendix

Items Used in the Experiments

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<th>Morphemic</th>
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<th>Pseudosyllabic</th>
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<td>CALTRUDE, CALPRISE</td>
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Received February 18, 1993
Revision received November 3, 1993
Accepted November 8, 1993