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Morphological families in the internal lexicon

THE QUESTION addressed in this study is whether the speed with which a word is recognized depends upon the frequency of related words, and which types of related words have such an influence. For example, does the speed of recognition of the word *stair* depend at all on the frequency of *stairs* (an inflectional relative)? Is the speed with which people recognize *govern* influenced by their knowledge of the word *government* (a derivational relative)? Is the recognition of *fee* influenced by the simple fact that the letters overlap with the letters in familiar words such as *feet, feed,* and *feel* (nonmorphological relatives)? The authors asked 95 U.S. college students to distinguish stem words from nonwords in a lexical decision task. The stem words were matched for length and individual frequency, but differed substantially in the frequency of their inflectional, derivational, or nonmorphological relatives. The researchers found that the frequency of inflectionally and derivationally related words significantly affected speed and accuracy of recognition of stems; however, these effects were conditioned by the likely age of acquisition for each word, and by the part of speech. Extensive analyses showed that simple letter overlap did not have a significant effect on word recognition. Taken as a whole, the results support the concept of morphologically based word families, that is, the hypothesis that morphological relations between words, derivational as well as inflectional, are represented in the lexicon.

Les familles morphologiques dans le lexique mental

LA PRÉSENTE RECHERCHE vise à vérifier dans quelle mesure la vitesse de reconnaissance des mots est influencée par la fréquence des mots associés et dans quelle mesure elle varie en fonction de la nature des relations entre les mots. Par exemple, est-ce que la vitesse de reconnaissance du mot *escalier* est influencée par la fréquence du mot *escaliers* (mot associé par une relation inflexionnelle)? Est-ce que la vitesse de reconnaissance du mot *gouverner* est fonction de la fréquence du mot *gouvernement* (mot associé par une relation dérivative)? Est-ce que la reconnaissance du mot *amertume* est lié à la fréquence du mot *amerrissage* (mot associé seulement par une relation graphique)? La recherche impliquait 95 étudiants de niveau collégial. La tâche de décision lexicale consistait à distinguer entre des mots racines et des non-mots. Les mots racines étaient pairés en fonction de leur longueur et de leur

fréquence, mais différaient de façon substantielle quant à la fréquence des mots associés soit par des relations inflexionnelles, dérivatives ou graphiques. Les résultats confirmèrent l'influence de la fréquence des mots associés inflexionnellement ou dérivativement sur la vitesse de reconnaissance des mots racines. Cependant, ces effets sont fonction de l'âge probable d'acquisition des mots et de la catégorie de mots. Le simple recouvrement de lettres (relation graphique) n'a aucun effet. Dans l'ensemble ces résultats confirment le concept de familles de mots constituées autour de relations morphologiques, soit inflexionnelles ou dérivatives, et la conception selon laquelle le lexique mental est ainsi constitué.

Familias morfológicas en el lexicón interno

EL PROBLEMA en cuestión en este estudio es averiguar si la velocidad a la que una palabra es reconocida depende de la frecuencia de palabras relacionadas, y qué tipos de las palabras relacionadas tienen esa influencia. Por ejemplo, ¿la velocidad de reconocimiento de la palabra *escalera* depende de alguna manera de la frecuencia de *escaleras* (relacionada de forma inflecciónal)? ¿La velocidad a la que la gente reconoce la palabra *gobernar* está influída por su conocimiento de la palabra *gobierno* (relacionada por derivación)? ¿Está el reconocimiento de *paje* influído por el simple hecho que las letras son las mismas que en otras palabras familiares tales como *paja* y *pájara* (relacionadas de forma no morfológica)? Los autores pidieron a 95 estudiantes universitarios estadounidenses que distinguieran palabras raíz de palabras sin sentido en una tarea que implicaba decisión léxica. Las palabras raíz fueron apareadas tanto en longitud como en frecuencia individual, pero difiriendo substancialmente en la frecuencia de las palabras relacionadas de forma inflecciónal, derivacional y no morfológica. Se encontró que la frecuencia de palabras relacionadas de manera inflecciónal y derivacional afectó significativamente la velocidad y exactitud en el reconocimiento de las palabras raíz; sin embargo, estos efectos fueron condicionados por la probable edad de adquisición de cada palabra y por su posición gramatical. La similitud en la escritura (relación de forma no morfológica) no tuvo efecto alguno. Considerados en su totalidad, los resultados apoyan el concepto de familias de palabras con base morfológica, esto es, la hipótesis que las relaciones morfológicas entre las palabras, tanto de tipo derivacional como inflecciónal, están representadas en el lexicón.

Morphologische Wurzelfamilien im internen Lexikon

IN DIESER STUDIE werden die Fragen untersucht, ob die Geschwindigkeit, mit der ein Wort erkannt wird, von der Häufigkeit verwandter Wörter abhängt, und welche Arten verwandter Wörter einen solchen Einfluß ausüben. Hängt z.B. die Geschwindigkeit, mit der das Wort *Treppe* erkannt wird, prinzipiell von der Häufigkeit des Wortes *Treppen* ab (eine Flexionsverwandtschaft)? Ist die Geschwindigkeit, mit der Menschen das Wort *regieren* erkennen, davon abhängig, daß sie das Wort *Regierung* kennen (eine Derivationsverwandtschaft)? Wird das Erkennen von *Bau* durch die einfache Tatsache beeinflußt, daß die Buchstaben sich mit denen in bekannten Wörten wie z.B. *Baum, Bauch* und *Bausch* decken (nicht-morphologische Verwandtschaft)? Die Verfasser forderten 95 Studenten in einem Experiment auf, Stammwörter von Nicht-Wörten in lexikalischer Hinsicht zu unterscheiden. Die Stammwörter wurden in ihrer Länge und jeweiligen Häufigkeit zueinander geordnet, sie untershieden sich jedoch erheblich in der Häufigkeit ihrer Flexions-, Derivations- und nicht-morphologischen Verwandtschaft. Die Resultate zeigten, daß die Häufigkeit der flexions- und derivationsverwandten Wörter die Geschwindigkeit und Genauigkeit, mit der die Stämme erkannt wurden, beträchtlich beeinflußte; diese Auswirkungen waren jedoch bedingt durch den Zeitpunkt, zu dem jedes einzelne Wort gelernt wurde, und durch die Art des Satzgliedes, die sie darstellten. Das einfache Uebereinstimmen von Buchstaben hatte keinerlei Effekt. Insgesamt unterstützen die

Resultate das Konzept morphologisch-verwandter Wortfamilien, d.h. die Hypothese, daß morphologische Beziehungen zwischen Wörten, ob nun derivativer oder flektierender Art, im Lexikon dargestellt sind.

This study asks whether the morphology of words—that is to say, the structure of words in terms of prefixes, stems, and suffixes—plays a role in how words are represented in people's internal lexicons. A number of researchers have attempted to understand how words are stored in memory. Yet many important theoretical issues are still unresolved.

Our interest in this area is also motivated by concern for potential educational applications. An important characteristic distinguishing good readers from poor readers is the ability of good readers to recognize words with speed and efficiency. This difference appears to be more pronounced for longer words. Given that most longer words are morphologically complex, deficiencies in morphological knowledge may be a cause of poor readers' difficulties with long words (Anderson & Davison, 1988). Studies have found large differences between readers in their knowledge of English derivational morphology (Freyd & Baron, 1982; Gleitman & Wanner, 1982), which are associated with differences in reading ability (Tyler & Nagy, 1985).

We are interested, therefore, in determining the mechanisms by which morphological knowledge may contribute to efficient word recognition. Previous research has failed to find that words of greater morphological complexity are more difficult to process (Kintsch, 1974). In fact, research on the role of word frequency in word recognition suggests a mechanism by which knowledge of morphological relationships could facilitate word recognition of morphologically complex words: For sophisticated readers, at least, decomposing such words into parts could make them easier to process than other words of equal length and frequency, because the individual parts are often of higher frequency than the whole word. It is a well-established finding that words of higher frequency are recognized more quickly than words lower in frequency. *Stand* and *steed* are the same length, but *stand* is recognized much more quickly.

The best measure of the frequency of a word is thus probably not the frequency of that word alone, but the frequency of a *family of words* closely related in form and meaning. The word *inactivity*, for example, is a relatively low-frequency word, occurring less than once in a hundred million words of school text, according to the *American Heritage Word Frequency Book* (Carroll, Davies, & Richman, 1971). If word recognition were determined only by the frequency of the individual word, independent of morphological relationships, this word would be accessed relatively slowly. However, when related words such as *active*, *inactive*, *activity*, and *activities* are taken into account, the *family frequency* of *inactivity* is 10 thousand times as great as the frequency of this individual member. If family frequency plays any role in word recognition, *inactivity* should be accessed much faster than its frequency as an individual word would lead one to expect.

The overarching theoretical question about word families is how they are represented in people's internal lexicons. At one extreme is the possibility that all of the members of a word family share the same lexical entry, organized under the stem, and that inflectional and derivational affixes are stripped off before the entry is accessed. For example, when faced with *untie*, a person could set aside *un-*, look up the entry for *tie* in his or her internal lexicon, and then deduce that *untie* means to reverse the action of tying. At the other extreme is the possibility that every word has a separate and distinct entry. There are also several possibilities between these two. It could be, for instance, that regular inflections—and, perhaps, semantically transparent derivatives—share the entry with the stem, whereas more distant relatives have separate entries. Or it could be that the lexicon con-

tains separate, but linked, entries for different members of a word family.

The strong and dependable effect that frequency of usage has on speed of word recognition can be used as a tool to make inferences about how word families are represented in the mental lexicon. On the one hand, if the frequency of inflections and derivatives were to have as much impact on the recognition of a stem as the frequency of the stem itself, that would be strong evidence for a theory that the members of families share single entries. On the other hand, if the frequency of inflections and derivatives were to have no influence on recognition of the stem, that would be evidence for a theory that even closely related words have separate entries. In principle, we should also be able to discriminate between intermediate theories based on the pattern of the evidence.

Inferences about the structure of the subjective lexicon can also be made by examining how the frequency of a stem affects the speed and accuracy of recognition of its morphological relatives; in fact, most previous research has taken this approach. Four kinds of morphological relatives have generally been considered in previous studies: words with prefixes, words with inflectional suffixes, words with derivational suffixes, and compound words.

Taft (1979) studied words consisting of a prefix and a stem and found that reaction time on a lexical decision task was influenced by the frequency of the stem. For example, the words *dissuade* and *reproach* are of equal frequency. But the stem *proach* also occurs in the relatively frequent word *approach*, whereas the stem *suade* occurs in the less frequent word *persuade*. Taft found that the reaction time for words like *reproach* was shorter than that for words like *dissuade*. This finding seems to indicate that for prefixed words, reaction time is influenced by stem frequency, and not just by individual word frequency.

A variety of studies on regular inflections of words have indicated that the frequency of inflected forms influences the speed of recognition of the stem word (see reviews by Cutler, 1983; Taft, 1985). That is, the reaction time for *walk* appears to depend not only on the frequency of *walk*, but also on the frequency of *walks*, *walked*, and *walking*. A number of lexical decision studies have also been conducted using repetition priming instead of frequency as a basis for exploring morphological relationships. These studies have also found a strong relationship between stems and their regular inflections. For example, Stanners, Neiser, Hernon, and Hall (1979) found that a regular inflection, such as *thinks*, primes the stem, *think*, as much as the stem primes itself.

Compound words appear to be accessed via their component parts (Andrews, 1986; Taft, 1985). That is to say, the frequency of the component parts plays a role in how quickly compounds are accessed.

The picture is least clear in the case of derivational suffixes such as *-ness* or *-ion*, which change the part of speech of a word. Bradley (1979) found that the frequency of the stem influenced reaction times for some suffixed words—those ending in *-er*, *-ness*, and *-ment*—but not for words ending in the suffix *-ion*. This difference may relate to the type of suffix involved. Neutral suffixes, such as *-er*, *-ness*, and *-ment*, make few changes in the spelling or pronunciation of words they are added to, and are usually added only to stems that are words in their own right. Nonneutral suffixes, on the other hand, such as *-ion*, often make substantial changes in the spelling and pronunciation of stems they are added to (e.g., *destroy/destruction*), and are often added to stems that are not words themselves (e.g., *nation*).

Stanners and associates (1979) found that words with derivational affixes (either suffixes or prefixes) prime their stems less strongly than do the stem words themselves (or their regular inflections), suggesting that the derivatives constitute separate, though related, lexical entries. However, Fowler, Napps, and Feldman (1985), in an experiment designed to disentangle the effects of episodic and lexical priming, found that derivatives primed their stems as strongly as did inflections or the stems themselves.

One possible objection to much of the research cited is that the lexical decision task may not adequately represent normal reading. When the stimuli are predominantly complex words,

subjects may adopt a strategy of morphological decomposition not used in normal reading. For example, the morphological decomposition model proposed by Taft and Forster (1975) predicted that pseudoprefixed words, such as the word *uncle*, would be accessed more slowly than genuine prefixed words, such as *unlike*. However, when Rubin, Becker, and Freeman (1979) tested this prediction, they found a significant effect only when the stimuli consisted entirely of prefixed and pseudoprefixed words. They concluded that subjects may use stems to access prefixed words only when the stimulus set contains a large proportion of prefixed words. In a subsequent study, Taft (1981) claims to have answered the objections raised by Rubin et al. by using only prefixed words with bound stems, which do not constitute words in themselves without the prefix (e.g., *rejoice*), and pseudoprefixed words, in which the initial letters are identical to English prefixes, but do not function as prefixes in these words (e.g., *prosaic*). However, one could still argue that because every word in Taft's (1981) stimulus set contains a letter string that could be a prefix, readers may invoke a strategy of prefix-stripping not used in normal reading.

Andrews (1986) explored the same objection in the case of derivationally suffixed words. She found that stem frequency affected the reaction time for derivatives, but only when most of the items were derivatives and compound words. Andrews concluded that subjects adopt special strategies when the stimuli are predominantly complex words. Bradley's (1979) results for derivational suffixes may be subject to the same criticism. In one of the experiments, for example, about half of the stimuli ended in the suffix *-ness*. To decide whether the stimulus was a word, all the subject had to do was to strip off the suffix and determine whether the remainder was a word. It is quite likely, then, that subjects' performance in this experiment did not reflect the strategies they would use in normal reading.

All in all, previous research does indicate that morphological relationships between words are represented in some way in the internal lexicon. However, the evidence is stronger for inflectional relationships than for derivational relationships. There is little evidence concerning the contribution of derivational relationships to the effects of frequency on word recognition. This last issue is the primary concern of the present study. One way—although not the only way—in which a working knowledge of derivational morphology may contribute to skilled reading is by facilitating faster word recognition.[1]

In the present study we extended previous research in several ways. First of all, we sought to avoid including a large proportion of morphologically complex words in the lexical decision task, which might influence subjects to adopt morphological decomposition as a special strategy not characteristic of their normal reading. In most studies to date, researchers have asked what effect the frequency of a stem has on the reaction time for a related complex form. For example, does the speed with which someone recognizes a complex word, such as *quietness*, depend on the frequency of the stem, *quiet?* Such studies necessarily include a large proportion of derived words, which may lead subjects to adopt limited-scope strategies. In the present study, we addressed a different but related question: Does the speed with which a person recognizes a stem, such as *quiet*, depend only on the frequency of the stem, or is it influenced by the frequency of relatives, such as *quietly* and *quietness?* To answer this question, one does not need to include any morphologically complex words in the stimulus set; therefore, there are no cues to sensitize subjects to morphological relationships, and no reason for them to employ special strategies. If the reaction time for *quiet* is influenced by the frequencies of *quietly* and *quietness*, this influence must come from the subjects' prior experience with these words.

Second, in the present study we examined three kinds of word relatedness, whereas previous studies usually have focused on one kind of relatedness. We included words related by inflectional morphology, words related by derivational morphology, and words that were not

morphologically related but shared letters. Thus, the study aimed to provide a broad assessment of the concept of a word family.

Third, in this study we examined the role of other factors in determining which kinds of relationships between words influence word recognition and condition the effect of frequency. Reisner (1972, cited in Taft, 1985) claimed that stem frequency influences reaction times for suffixed words, but only suffixed words of lower frequency. Other factors known to affect reaction time, such as word length, age of acquisition (e.g., Brown & Watson, 1987; Gilhooly, 1984), and number of meanings (Jastrzembski, 1981) may also condition the effect of frequency. It may be, for example, that suffixed words that were acquired relatively early are usually recognized without analysis into parts. However, aside from Reisner (1972), few researchers have paid attention to factors that might mediate the role of morphological relatedness in word recognition. In this study, a number of word variables were taken into account: age of acquisition, part of speech, abstractness, estimated frequency in oral language, position of the stressed syllable, number of distinct meanings, relative frequency of the stem and its most frequent derivative, part of speech of the most frequent derivative, formal relationship between the stem and its most frequent derivative, semantic transparency of the relationship between the stem and its most frequent derivative, and, of course, word length.

Fourth, in the present study we included a greater number and variety of words, and a larger number of subjects, than were included in most previous studies of the role of frequency in word recognition. Smaller word samples or subject populations are worrisome because estimates of the true frequency of infrequent words are inherently unstable (Carroll et al., 1971), and because subjects are likely to have idiosyncratic patterns of exposure to infrequent words (Nagy & Anderson, 1984). Thus, inclusion of ample numbers of words and subjects may be crucial when the effects of frequency are being investigated.

Method

Subjects

Subjects were 109 undergraduates from a large university in the Midwestern United States. Participation in the study was partial fulfillment of a course requirement. The data from 14 subjects were lost due to equipment failure.

Target words

In selecting the target words, the basic idea was to choose pairs of words that were matched for length and individual frequency, based on the *American Heritage Word Frequency Book* (Carroll et al., 1971), but so that words related to the two members of each pair differed greatly in frequency. There were 3 sets of 28 pairs of words, for a total of 168 words.

The first set consisted of pairs that differed in terms of frequency of the inflectional family, defined as the sum of the frequencies of all of the inflections of the target word, including the comparative and superlative degrees of adjectives. Table 1 gives an example of a pair of words from this first set. As can be seen in the table, *stair* and *spike* are equal in frequency. However, the frequency of the plural *stairs* is much higher than the frequency of *spikes* and *spiked* combined. In this set of words, we essentially replicated one of the experiments by Taft (1979).

The words in the second set of 28 pairs differed primarily in terms of derivational family frequency, defined as the sum of the frequencies of all derivatives of the target word. Table 2 gives an example of such a pair: *Slow* and *loud* are identical in frequency, but there is a large difference in frequency between *slowly* and *loudly*. Thus, the derivational family frequency of *slow* is three times that of *loud*.

The third set of 28 word pairs differed in terms of nonmorphological overlap, defined as the sum of the frequencies of all words that include the target word as an embedded letter string, but which have no morphological relationship to the target word. Table 3 contains such a pair of words: The words *fee* and *cod* are

Table 1 Sample word pair differing primarily in frequency of inflectional relatives

	Word 1			Word 2		
Relationship	Word	Word frequency	Family frequency	Word	Word frequency	Family frequency
Target word	stair	2.4		spike	2.4	
Inflections	stairs	29.4	29.4	spikes	3.1	
				spiked	0.9	
					4.0	4.0
Derivatives	stairway	5.5		spiky	0.3	0.3
	staircase	2.6				
		8.1	8.1			
Nonmorphological relatives	–		0.0	–		0.0

Note. Frequency is per million words of text.

Table 2 Sample word pair differing primarily in frequency of derivational relatives

	Word 1			Word 2		
Relationship	Word	Word frequency	Family frequency	Word	Word frequency	Family frequency
Target word	slow	68.7		load	69.1	
Inflections	slowed	11.4		loader	18.5	20.0
	slowing	4.0		loadest	1.5	
	slows	3.0				
	slower	8.5				
	slowest	0.6				
		27.5	27.5			
Derivatives	slowly	205.0	205.0	loudly	21.5	
				loudness	1.6	
				loudspeaker	1.6	
					24.7	24.7
Nonmorphological relatives	–		0.0	–		0.0

Note. Frequency is per million words of text.

equal in frequency. However, the letter sequence *f-e-e* occurs in words that are much higher in frequency, especially *feel* and *feet*. The letters *c-o-d*, on the other hand, occur only in words such as *code*, *coddle*, and *coda*, which are much lower in frequency than *feel* and *feet*.

As an aid to generating candidate words, a computer program was written that would

Table 3 Sample word pair differing primarily in frequency of nonmorphological relatives

	Word 1			Word 2		
Relationship	Word	Word frequency	Family frequency	Word	Word frequency	Family frequency
Target word	fee	3.1		cod	3.3	
Inflections	fees	1.5	1.5	–		0.0
Derivatives	–		0.0	codfish	1.5	1.5
Nonmorphological relatives	feeble	2.7		code	21.5	
	feed	65.6		codes	1.2	
	feeder	3.2			22.7	22.7
	feeding	20.9				
	feeds	7.9				
	feel	226.8				
	feelers	4.3				
	feeling	87.8				
	feelings	37.1				
	feels	30.4				
	feet	463.3				
		950.0	950.0			

Note. Frequency is per million words of text.

search the American Heritage corpus (Carroll et al., 1971) for words that contained a given stem as an orthographic substring. To these word families produced by the computer, we added the irregular inflections and nonneutral derivatives of each word. Then the aggregate frequency of each family was calculated. If the family frequency was at least 4 times greater than the frequency of the stem, then the stem word became a candidate for a high-family-frequency word. If the family frequency was less than 1½ times the frequency of the stem, then the stem word became a candidate for a low-family-frequency word.

For each candidate item, we had a set of words related by morphology or incidental orthographic overlap. Each member of this set was coded according to the relationship it bore to the stem: inflectional, derivational (including prefixed words, suffixed words, compound words, and irregular derivations such as *pride* and *proud*), or nonmorphological. Words related to the stem by nonmorphological overlap were further categorized according to consistency of pronunciation—that is, into those for which pronunciation was the same (e.g., *fee/feet*), and those for which it changed (e.g., *cod/code*).

Finally, from these candidates we selected three sets of word pairs that were matched in length and stem frequency, but differed in the frequency of their inflectional, derivational, and nonmorphological relatives, respectively. For each set, we tried to select word pairs that maximized the difference in frequency of the type of word family contrasted in the set, and minimized—but did not completely eliminate—differences in frequency of the other two types. Also, for each set we chose word pairs that encompassed a range of stem frequencies and lengths (from 3 to 8 letters). An attempt was also made to match the three sets for overall distribution of items by length and frequency, but because of the limited number of candidates fulfilling other constraints, the words in the third set were shorter and of lower frequency than those in the other two sets.

Four trained raters coded the final sets of target words on a number of other word properties, and any differences were resolved in conference. The other word properties were as follows:

Age of acquisition. The age at which subjects were likely to have first learned the meaning of the word was rated on a 4-point scale: (a) preschool, (b) Grades 1–6, (c) Grades 7–12, or (d) after high school. In this case, 10 raters were used, and the mean score for each word was used in the analysis.

Number of syllables.

Position of stressed syllable.

Bigram frequency. The sum of the frequencies of all bigrams (letter pairs) in each word was computed on the basis of Mayzner and Tresselt (1965). Bigram frequency tables were also constructed using Carroll et al. (1971), and sums of bigram frequencies based on these tables were computed for each stimulus word.

Part of speech of stem. Each target word was coded as a noun, a verb, or an adjective. When the part of speech was ambiguous (e.g., *burn* could be a noun or a verb), the code reflected the part of speech of the base of the most frequent derivative. For example, the most frequent derivative of *burn* is *burner,* which, though itself a noun, is derived most directly from the verb *burn.* Thus, *burn* was coded as a verb.

Number of distinct meanings. Raters were asked to think in terms of truly distinct, unrelated meanings.

Abstract versus concrete. Raters were asked to categorize stimulus words as either abstract or concrete. Object names (e.g., *corpse, star*) and other highly imageable words that could be taken as nouns (e.g., *dent, rash*) were rated as concrete. Other words (e.g., *success, teach, guilt*) were rated as abstract.

Frequency of stem compared to its relatives. Stems were coded as either (a) higher in frequency than any other family member, or (b) having at least one relative of higher frequency than the stem.

Frequency in oral language. Stems were coded as (a) occurring more frequently in written than in oral language, (b) occurring in both written and oral language with approximately the same frequency, or (c) occurring more frequently in oral than in written language.

Part of speech of most frequent derivative. The most frequent derivative of each stem was identified, and its part of speech was coded. In almost all cases, there was one derivative far more frequent than any other.

Formal relationship of most frequent derivative to stem. The most frequent derivative was classified as composed of (a) a neutral prefix, such as *non-*, (b) a nonneutral prefix, such as *con-* or *ab-*, (c) a neutral suffix, such as *-ness* or *-ful*, (d) a nonneutral suffix, such as *-ity* or *-ion*, (e) a compound, such as *corkscrew* or *lampshade*, or (f) an irregular derivative, as *pride* is a derivative of *proud.*

Semantic transparency of relationship of most frequent derivative to stem. The semantic relationship was coded on a 3-point scale: (a) transparent, as in the pair *educate/education,* (b) translucent, as in the pairs *detect/detective and roost/rooster,* or (c) opaque, as in the pairs *lard/larder and sandal/sandalwood.*

Apparatus

Subjects performed the lexical decision task on IBM-AT personal computers in a university computer lab that could accommodate up to 20 students at a time. A software program was written to utilize the internal clock of these computers. This program interrupted other processing when a response key was pressed. Thus, the program eliminated any variability in timing that might have been introduced if other computations were being performed during the measurement of response times.

Procedure

First, we gave the subjects a paper-and-pencil wide-range vocabulary test (French, Ekstrom, & Price, 1963) as a measure of ability. We then asked subjects to look at the computer screen, on which was displayed instructions for the lexical decision task. We read these instructions aloud as subjects followed along.

In this task, the stimulus word or nonword appeared in the center of the screen of the computer, in lowercase, 18-point IBM standard font. It appeared 1500 msec after the subject pressed the space bar to signal readiness for the next stimulus. The stimulus remained on the screen until the subject responded. Subjects were instructed to use their index fingers to press a "YES" key if the stimulus was a word, and a "NO" key if it was not a word. The dominant hand was always used for the "YES" response. In order to ensure that subjects would be fixating the correct region of the display when the stimulus was presented, a pointer was displayed on the screen that indicated, but did not mask, the position where the stimulus would appear.

The complete stimulus set consisted of the 168 target words, 168 nonwords matched for length, and 24 practice items (half words, half nonwords). Nonwords conformed to the constraints of English spelling. The order of items was randomized individually for each subject.

Data analysis

In the primary data analyses, within-subject analyses of variance were used to compare subjects' performance on the three sets of word pairs, which were matched with respect to frequency and length, but differed with respect to the frequency of inflectional, derivational, or nonmorphological relatives. The dependent variables were the proportion of errors and the reaction time for a correct response on the lexical decision task. The proportion of errors was normalized with an arcsine transformation. Reaction times shorter than 200 msec were discarded, and times greater than 5 seconds were recoded to 5 seconds. Reaction time was then normalized with a logarithmic transformation. A logarithmic transformation was also used to normalize the distributions of word frequencies and linearize their relationships with the proportion of errors and reaction time.

Subsidiary analyses, in which the word was the unit of analysis, were completed within the framework of the general linear model. The dependent variables in these analyses were the mean log reaction time for correct responses, and the proportion of errors. The logit transformation was used to normalize the distribution of error rates. The subsidiary analyses examined not only the effects of family frequency, but also the extent to which other variables, such as stem frequency, age of acquisition, and word length, might condition the effects of family frequency. Analyses were performed separately on the three sets of target words and on the combined set.

Results

The mean reaction times and proportions of errors on the lexical decision task appear in Table 4. For all three sets of target words, subjects responded significantly more quickly to the word in each pair for which the total frequency of the family of related words was greater—whether the relationship was inflectional, derivational, or purely orthographic (nonmorphological). The error data, however, showed a slightly different pattern. For the first two sets, representing inflectional and derivational relationships, subjects made fewer errors on words with higher family frequencies. For the third set of words, however, the family frequency of orthographically overlapping words did not significantly influence subjects' error rates.[3] In the following sections, we will examine the results for each set of words in detail.

Inflectional relationships

For the first set of words—pairs of words differing primarily in the frequency of their inflections, like *stair* and *spike*—subjects responded significantly more quickly to words with higher inflectional family frequencies, $F(1, 94) = 39.2$, $p < .001$. They also made fewer errors on these words, $F(1, 94) = 35.5$, $p < .001$.

Results of regression analyses for the first set of words, with reaction time as the dependent variable and the word as the unit of analysis, are given in Table 5. There is a significant effect of inflectional frequency; however, this effect disappears if age of acquisition is in-

Table 4 Mean reaction times (in msec) and error rates (%) for three sets of word pairs

Family frequency contrasted	Reaction time	Error rate
Inflectional		
High	720	3.7
Low	759	7.6
Derivational		
High	730	2.7
Low	741	5.6
Nonmorphological		
High	781	12.8
Low	795	14.4

Note. Figures have been backtransformed from mean log reaction time and mean arcsine proportion of errors.

cluded in the analysis. (In this and the ensuing tables, reduced regression models are given, in which factors not involved in significant effects are not shown.)

A similar analysis was conducted using the error rate (normalized using the logit transformation) as the dependent variable, and the word as the unit of analysis. In this analysis, the effect of inflectional frequency on error rate was not significant, $F(1, 54) = 3.5, p > .05$.

Derivational relationships

For the second set of words—pairs of words differing primarily in the frequency of their derivations, like *slow* and *loud*—subjects responded significantly more quickly to words with higher derivational family frequencies, $F(1, 94) = 9.0, p < .01$. They also made fewer errors on such words, $F(1, 94) = 42.1, p < .001$. These results support the hypothesis that derivational relationships between words play a role in word recognition.

The results of a regression analysis on the second set of words using the word as the unit of analysis are given in Table 6. In this analysis, the main effect of derivational family frequency was not significant (regardless of whether age of acquisition was included in the analysis). However, a significant interaction was found between derivational frequency and part of speech (coded in orthogonal contrasts); derivational frequency speeded recognition of nouns and verbs, but not adjectives. In short, derivational relationships do appear to make a contribution to the effect of frequency on word recognition, but this effect does not appear to generalize across all kinds of words.

A similar analysis was done using the transformed error rate as the dependent variable, and the word as the unit of analysis. In this analysis, the effect of derivational family frequency on error rate was not significant, $F(1, 54) = 1.05, p > .05$.

Nonmorphological relationships

In the third set of words, nonmorphological relationships had a significant effect on reaction time when the subject was the unit of analysis, $F(1, 94) = 10.6, p < .01$. However, the difference in error rates for subjects was not significant, $F(1, 94) = 2.37, p > .05$.

In regression analyses using the word as the unit of analysis, the effect of nonmorphological relationships on reaction time was not significant. Table 7 displays this analysis. Some of the words in the third set had not only nonmorphological relatives, but also derivational relatives, such as *codfish* (see Table 3). As is evident from the analysis presented in Table 7, these true derivatives, although much lower in frequency than the nonmorphologically related words, had a highly significant effect on reaction time.

The interaction between derivational frequency and part of speech found in the second set of target words was not found for this third set of words. However, the third set turned out to be composed almost entirely of nouns, and nouns (and verbs) in the second set were influenced by derivational frequency. Thus, one would expect to find a significant effect of derivational frequency with the third word set, so the two analyses yield consistent findings after all.

The effect of the derivational relationships in this third set of words may explain the signif-

Table 5 Multiple regression analysis for words in pairs differing primarily in inflectional family frequency

Variable	F	R^2	R^2 change	Simple r
		Without age of acquisition		
Stem frequency	24.4*	.33	.33	-.58
Inflectional frequency	9.1*	.46	.12	-.58
		With age of acquisition		
Age of acquisition	36.7*	.38	.38	.62
Age of acquisition squared	7.9*	.47	.08	.66
Stem frequency	9.9*	.57	.10	-.58
Inflectional frequency	1.0	.58	.01	-.58

*Critical value: $F(1, 55) = 4.02$, $p < .05$

Table 6 Multiple regression analysis for words in pairs differing primarily in derivational family frequency

Variable	F	R^2	R^2 change	Simple r
Stem frequency	58.9*	.54	.54	-.74
Age of acquisition	7.3*	.61	.07	.69
Age of acquisition squared	5.6*	.66	.05	.72
Derivational frequency	0.2	.66	.00	-.38
Part of speech	0.7	.67	.00	–
Derivational Frequency × Part of Speech	5.3*	.72	.05	–

*Critical value: $F(1, 55) = 4.02$, $p < .05$

icant effect of nonmorphological family frequency in the analysis using the subject as the unit of analysis. In additional analyses using the subject as the unit of analysis, the pairs of words in the third set were divided into three groups: (a) those with no derivational relatives that might contribute to a difference in reaction times, (b) those for which the effect of the frequency of derivational relatives would coincide with any effect of nonmorphological relatives, and (c) those for which the effect of the frequency of derivational relatives would be in the opposite direction to the effect of nonmorphological relatives.

For the first group of words—those for which derivational family frequency played no role—the effect of nonmorphological relationships was small but significant, $F(1, 94) = 4.85$, $p < .05$; words with higher-frequency nonmorphological relatives were recognized a little more quickly. For the second group, in which the frequency of derivational and non-

Table 7 Multiple regression analysis for words in pairs differing primarily in nonmorphological family frequency

Variable	F	R^2	R^2 change	Simple r
Age of acquisition	37.6*	.37	.37	.61
Word length (in letters)	5.9*	.43	.06	-.13
Derivational frequency	17.6*	.60	.17	-.58
Nonmorphological frequency	0.3	.61	.00	-.07

*Critical value: $F(1, 55) = 4.02, p < .05$

Table 8 Multiple regression analysis for all words

Variable	F	R^2	R^2 change	Simple r
Stem frequency	160.0*	.43	.43	-.66
Age of acquisition	34.9*	.53	.09	.65
Age of acquisition squared	8.4*	.55	.02	.66
Word length (in letters)	5.9*	.56	.02	-.18
Derivational frequency	10.3*	.59	.03	-.51
Part of speech	1.7	.60	.01	–
Derivational Frequency × Part of Speech	7.0*	.62	.02	–

*Critical value: $F(1, 55) = 4.02, p < .05$

morphological relatives coincided in direction, there was a strong effect, $F(1, 94) = 22.0, p < .001$. For the third group of words, the difference was significant, $F(1, 94) = 6.48, p < .05$, and in the opposite direction. That is, in the third group, it was the frequency of the derivational relatives, not of the nonmorphological relatives, that predicted which words were recognized most quickly. It should be noted that this was the case even though the magnitude of the frequencies of nonmorphological relatives was much greater than the magnitude of the frequencies of the derivational relatives.

An analysis was also performed using the transformed error rate as the dependent variable, and the word as the unit of analysis. In this analysis, the effect of derivational frequency on error rate was significant, $F(1, 54) = 7.14$, $p < .01$. Nonmorphological relationships did not significantly affect error rate.

Analysis of combined sets

Table 8 presents the results of an analysis of all the target words together. When the entire stimulus set is considered, the effect of derivational frequency is significant, as is the Derivational Frequency × Part of Speech interaction.

Other word properties

In the subsidiary analyses of the second and third sets of stimulus words, other word properties were investigated to see whether they might

condition the effect of derivational frequency on reaction time. We investigated both properties of the stimulus words, such as stem frequency, age of acquisition, length in letters and syllables, abstractness or concreteness, position of the stressed syllables, number of distinct meanings, relative magnitude of oral and written frequencies, and whether the most frequent derivative was more or less frequent than the stem; and properties of the most frequent derivative of the stimulus word, such as type of derivative (prefixed, suffixed, or compound word), part of speech of the derivative, semantic transparency of the derivational relationship, and whether the prefixes and suffixes were neutral or nonneutral. We found no significant main effects, except as already noted. Nor were any of the possible two-way interactions of these variables with derivational frequency significant. In particular, neither measure of bigram frequency made a significant contribution to predicting reaction time.

Ability

Subjects' verbal ability, as represented by the score from the wide-range vocabulary test, did not interact with any measure of family frequency in the analyses using the subject as the unit of analysis. We interpret this finding as showing that the derivational relationships represented in our materials were generally known to all the college undergraduate subjects.

Discussion

The primary purpose of this study was to determine the effect of relationships between words on word recognition—specifically, the extent to which speed and accuracy in identifying stems are influenced by the aggregate frequency of related words, and for what types of relationships between words this influence may hold. At issue is how related words are represented in the internal lexicon. At one extreme is the hypothesis that every word has a completely separate entry. At the other extreme is the hypothesis that morphologically complex words are always accessed through their component stems.

We found significant effects of inflectional and derivational family frequency on the speed and accuracy of identification of stem words. These findings clearly rule out the theory that the lexicon consists of totally unconnected entries. At the opposite extreme, the theory that a derived or inflected word is always accessed via its stem can be evaluated by comparing the effect of stem frequency on reaction time with the effect of inflectional and derivational family frequency. For example, if the lexical entry for the word *joins* is accessed via the entry for *join*, then every encounter with *joins* will have the same effect as an encounter with *join*. Therefore, if the theory is correct, the frequency of *joins* will contribute as much to the priority (or strength, position in push-down stack, activation threshold, etc.) attached to the *join* entry as does the frequency of the stem *join* itself, and thus have the same effect on speed of access.

In fact, our data show that the effect of the frequency of morphologically related words on the reaction times for stems, though significant, is not as strong as the effect of the frequency of the stems themselves. Regression analyses were performed in which the effects of inflectional, derivational, and stem frequency on reaction time were examined independently, to give each type of frequency full credit for any shared variance. The resulting regression equations were then used to calculate the change in reaction time resulting from a tenfold gain in frequency—for instance, from 10 times in a million words of text to 100 times in a million words of text. A change in stem frequency of this size leads to a 63 msec decrease in reaction time. A change in inflectional family frequency of the same size leads to a 19 msec decrease, and a change in derivational family frequency, to a 20 msec decrease. In other words, encounters with the words *decided* and *decision* affect the speed of a person's future response to the word *decide*, but not as strongly as does an encounter with the word *decide* itself.

Nonmorphological relationships have the opposite effect. A tenfold increase in the frequency of nonmorphological relatives results in

a 7 msec *increase* in reaction time. Among those words that share letters but differ in pronunciation (e.g., *code* and *cod*), the effect is to slow down word recognition even more; a tenfold increase in the frequency of such nonmorphological relatives leads to a 23 msec increase in reaction time.

Our theory to explain these results is that the lexicon is organized so that the entries for related words are linked. Accessing any one of the entries causes partial activation (cf. Stanners et al., 1979) of related entries. Thus, there are subentries under the stem—or linked main entries—for *join, joins,* and *joint,* and for *decide, decided,* and *decision,* and accessing one of the words in either family partially activates other family members.

Note the equivalence in size of the effects of inflectional and derivational frequency on reaction time for the stem. Linguistic theory and previous findings leave little doubt that inflectional relationships must be represented in the internal lexicon in some way. From the equivalence of the effect size we conclude, despite some complications in our results, that derivational relationships are represented in the lexicon as well.

It is important to determine not only *whether* relationships between words are represented in the internal lexicon, but also *which* relationships. Our results suggest that only morphological relationships are important, and not simple overlap of word parts. To be sure, our results were complicated by the chance correlation between the frequency of nonmorphologically related words and the frequency of derivational relatives. When this confound was statistically discounted, however, the apparent effect of frequency of nonmorphologically related words on reaction time nearly disappeared. Moreover, the effects of nonmorphological relationships did not even approach significance in analyses in which the word was the unit of analysis. Indeed, in the regression analyses, the sign of the coefficients pointed in the wrong direction when inflectional and derivational family frequency were in the equation. The lack of a significant effect of bigram frequencies on reaction time also supports the conclusion that the relationships that play a role in speeding word recognition are morphological, rather than simply orthographic. Thus, our findings are consistent with those of Murrell and Morton (1974), who found effects of inflectional relationships between words, but no effects of nonmorphological relationships that involved the same degree of orthographic similarity as the inflectional relationships.

Results of other studies (e.g., Taft, 1979) would lead to the expectation that inflectional frequency would strongly influence reaction time for recognition of stems. Hence, it may appear puzzling that the effect of inflectional frequency on reaction time for stems disappeared when age of acquisition was included in the analysis. Our explanation is that inflectional frequency may be naturally confounded with age of acquisition. For example, in a pair of words like *stair* and *spike,* not only is the inflection *stairs* more frequent than the stem, *stair,* but also *stairs* is acquired much earlier. In addition, age-of-acquisition ratings probably include a component of subjective frequency, and subjective frequency probably is influenced by inflectional family frequency.

Results from other types of experiments make it clear that inflectional frequency should be expected to influence reaction time. Therefore, we interpret our results as showing not that inflectional frequency fails to influence reaction time, but that it is difficult to distinguish the effects of inflectional frequency from the effects of age of acquisition in a lexical decision experiment of this sort. Nevertheless, the results do suggest that the findings of previous research, which did not take age of acquisition into account, should be interpreted with more caution.

The primary question addressed in this study is the status of *derivational* relationships. Previous research on this question is equivocal. Bradley (1979) found effects of stem frequency on the reaction time for recognizing derivatives for some suffixes but not others. Andrews (1986), however, found stem frequency did affect reaction time for suffixed derivatives, but only when the stimulus list contained large numbers of complex words. Andrews did find

effects of stem frequency for compounds. However, the results of both Andrews and Bradley could also be due to the subjects' adoption of special strategies when confronted with mostly complex words. The present experiment constituted a stringent test of the claim that the entries of stems and derivatives are interconnected, because the stimulus set contained no morphologically complex words. Hence, there was no reason for subjects to bring into play any strategy that entailed focusing on morphological relationships.

There is one possible reason why we found frequency effects for derivational relationships whereas Andrews (1986) did not: There may be asymmetries in the priming or activation relationships between related entries. Derivatives contain their stems, but not vice versa. That is, when one accesses the word *painful*, if the entries are related, one must also activate the word *pain* to some extent. On the other hand, it may be possible to access the word *pain* without activating *painful*. In fact, Stanners, Neiser, and Painton (1979) found that *unhappy* fully primed *happy*, whereas *happy* did not fully prime *unhappy*.

Because all the stimuli in the present experiment were stems, different types of derivational relationship were not directly represented. However, for almost all the stimulus words with a high derivational family frequency, there was a single derivative that was much more frequent than any other, and which accounted for most of the derivational family frequency. In the second set of stimulus words, all but one of the 28 stem words with high derivational frequency had a suffixed word as its most frequent derivative. Of the 27 suffixed words, 17 had neutral suffixes, and 10 had nonneutral suffixes. However, the neutrality of the suffix had absolutely no influence on the extent to which derivational frequency affected reaction time for the stem ($F < 1$). This result is inconsistent with Bradley's (1979) finding that stem frequency decreases reaction time for derivatives terminating with the neutral suffixes *-er*, *-ness*, and *-ment*, but not for derivatives ending in the nonneutral suffix *-ion*. In addition, half of the 56 words in the third set of stimulus words had derivatives that appeared in the American Heritage listing (Carroll et al., 1971). For 14 of these words, the most frequent derivative was a compound; for 13, the most frequent derivative was a suffixed word. (All but one of the suffixed derivatives had a neutral suffix.) However, whether the most frequent relative was a compound or a suffixed derivative had no influence on the extent to which derivational frequency affected reaction time for the stem ($F < 1$).

We were surprised that it did not seem to matter whether a derivative was neutral or nonneutral, but we were even more surprised by the Derivational Frequency × Part of Speech interaction: Derivational family frequency influenced reaction time for verbs and nouns but not adjectives. We do not know of any similar finding in the literature, nor of any psycholinguistic explanation why derivational family frequency should not affect reaction time for adjectives. As it happens, the most frequent derivatives of the adjectives employed in this study were all adverbs formed with the highly productive suffix *-ly*. One would have expected these words to show a stronger effect of derivational frequency, if anything. However, the Derivational Frequency × Part of Speech interaction tells us what was already evident from the lack of a significant effect on reaction time in the analysis by words: The frequencies of derived words influence speed of recognition for some stems, but not for others.

That part of speech is the critical factor seems implausible; the effect might be the result of some uncontrolled property of the adjectives or their relatives. Before lightly dismissing the effect of part of speech, though, it ought to be stressed again that in this study numerous properties that might condition the effects of derivational frequency were examined: properties of the stem, such as stem frequency, age of acquisition, length in letters and syllables, abstractness or concreteness, position of the stressed syllable, number of distinct meanings, relative magnitude of oral and written frequencies, and whether the most frequent derivative was more or less frequent than the stem; and properties of the most frequent deriv-

ative of the stem, such as type of derivational relationship, semantic transparency of the derivational relationship, and whether the prefixes and suffixes were neutral or nonneutral. But despite the rather exhaustive (and exhausting) search, no confounding variable was discovered which could explain the failure of derivational family frequency to affect speed of response to adjectives.

The results of this study have certain methodological implications for future research. When examining word frequency as one of the variables influencing speed of recognition, investigators may wonder whether to use simply the frequency of the word itself, or whether they should take the trouble to include the frequencies of inflections and derivatives. Although this study shows that the frequency of morphological relatives affects word recognition, it does not follow that family frequencies account for much variation in reaction times. Stem frequency is correlated with inflectional ($r = .35$) and derivational ($r = .47$) frequency, and the unique contribution of family frequencies is relatively small. As one adopts increasingly inclusive definitions of a *word family*, the gain in accuracy at predicting reaction times increases only slightly. Taking all our stimulus words together, the correlation between the log of reaction time and the individual word frequency is -.658. If one includes regular inflections in the computation of family frequency, the correlation between frequency and reaction time increases to -.695. However, if one includes derivational relationships as well, the correlation rises only to -.699, a very small gain. (If one goes on to include orthographically but not morphologically related words, the correlation drops to -.500.) In other words, if one is interested in accuracy at predicting reaction times, it might be worthwhile to take inflectional relationships into account, but adding up derivational frequencies is simply not worth the trouble.

On the other hand, our results indicate that as a practical (or methodological) matter, age of acquisition is a factor well worth taking into consideration. From the simple correlations in the tables, it is apparent that the age-of-acquisition ratings predict reaction time about as well as word frequency—better, if one takes the curvilinearity of the relationship between age of acquisition and reaction time into account. Obviously, there is a lot of overlap between frequency and age of acquisition; they correlate -.61. But age-of-acquisition ratings make a significant independent contribution to reaction time even when entered after frequency. It is especially surprising that a relatively low-cost measure—10 raters rating on a 4-point scale—had as much predictive power as frequencies based on a corpus of 5 million words.

To recapitulate, the present study supports the concept of a *word family*. The results suggest that morphologically related words are grouped together under the same entry in the internal lexicon, or perhaps in linked main entries. Most newsworthy was the finding that derivational family frequency had the same effect on stem reaction time as did inflectional family frequency. Passing over the complication involving adjectives, this result makes the prima facie case that derivatives and inflections are represented in a comparable manner in the lexicon.

Andrews' study (1986) showed that morphological decomposition is a strategy that skilled readers *can* adopt, given special task demands. However, in Andrews' study, subjects did not adopt this strategy unless the stimulus materials contained a high proportion of complex words. This result would imply that, during normal reading, skilled readers' knowledge of derivational morphology does not play a role in word recognition. Our results indicate the opposite. Because we were looking at the effect of derivational frequencies on reaction times for stems, our results do not reflect any morphological decomposition that may take place during a lexical decision task. Rather, they are the cumulative results of morphological decomposition during the subjects' years of language use. Thus, the present study strongly suggests that knowledge of morphology plays a role in word recognition during normal reading.

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Footnotes

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[1]Knowledge of derivational morphology is likely to play an even more crucial role in trying to understand new words. More than 60% of the new words that readers encounter have relatively transparent morphological structures—that is, they can be broken down into parts, at least some of which are words themselves, and the meanings of these parts give sufficient information to make a good guess at the meaning of the whole word (Nagy & Anderson, 1984).

[2]As can be seen in Table 4, the stimuli in the third set of words resulted in longer reaction times and higher error rates than those in the first two sets. This is probably because, as explained in the Methods section, a higher priority had to be placed on matching length and frequency in pairs within sets than matching overall length and frequency between sets. The stimulus words in the third set were, on average, shorter but less frequent than those in the other two sets.

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APPENDIX Frequencies and reaction times for three sets of words

Word	Reaction time	Frequency			
		Stem	Inflectional	Derivational	Nonmorphological
Word pairs differing primarily in inflectional family frequency					
flop	731	0.864	3.044	0.630	0.000
foam	857	0.845	0.000	0.011	0.000
wing	700	26.310	88.220	2.595	0.016
dull	670	25.274	0.770	1.235	0.395
burn	662	30.621	112.938	3.524	1.900
lamp	644	30.752	10.708	1.044	0.153
glove	667	6.302	8.435	0.000	0.011
grief	620	6.324	0.335	3.967	0.000
stair	645	2.515	29.367	7.916	0.000
spike	650	2.508	4.044	0.313	0.000
gland	703	2.864	8.609	0.918	0.000
quail	705	2.891	0.054	0.000	0.000
pebble	696	5.678	9.145	0.136	0.000
cradle	689	5.991	1.381	0.096	0.000
mitten	777	0.237	4.811	1.681	0.000
martyr	818	0.237	0.238	0.015	0.000
muscle	660	18.758	51.447	0.079	0.000
statue	693	20.269	3.437	2.052	0.000
bruise	688	0.570	4.579	0.015	0.000
chaste	753	0.578	0.000	0.074	0.000
termite	743	1.116	3.194	0.000	0.000
treason	750	1.121	0.000	0.011	0.000
glitter	662	1.211	8.911	0.000	0.000
methane	837	1.224	0.000	0.021	0.000
whisper	649	10.867	43.923	0.071	0.000
chimney	764	11.940	4.122	0.102	0.000
scatter	664	3.940	33.218	0.119	0.000
crimson	750	3.918	0.117	0.069	0.000
bean	702	12.483	31.506	0.911	0.004
fist	684	11.076	5.089	0.023	0.021
tuck	788	1.241	9.647	0.014	3.060
shun	821	1.141	0.262	0.012	0.170
wave	688	54.274	148.146	11.038	0.068
bowl	690	52.580	14.862	1.341	0.057
choke	662	1.093	6.677	0.021	0.000
latch	677	1.117	0.091	0.000	0.000
crush	640	3.132	16.427	0.023	0.000
slang	686	3.114	0.000	0.000	0.000
troop	672	3.987	26.762	1.275	0.000
spout	734	3.326	0.961	0.000	0.000
friend	638	155.041	195.239	69.695	0.000
spring	618	156.119	18.881	5.843	1.828
parent	620	8.628	80.348	1.076	15.478
carpet	642	8.743	3.235	0.180	0.000
sandal	831	0.534	3.002	0.000	0.549
mirage	800	0.502	0.119	0.000	0.000
mingle	727	0.552	2.885	0.000	0.000
gospel	699	0.746	0.011	0.000	0.000
attach	663	5.964	37.361	1.634	0.000
barley	726	6.903	0.000	0.054	0.000
grumble	735	0.686	5.424	0.000	0.000
trundle	816	0.806	0.146	0.000	0.000
stumble	670	1.949	9.525	0.116	0.000
stubble	703	1.726	0.113	3.958	0.070

install	660	2.022	8.434	4.283	0.000
sulphur	874	2.125	0.000	0.059	0.000

Word pairs differing primarily in derivational family frequency

reap	773	0.927	0.237	2.703	1.991
skew	837	0.928	0.000	0.290	0.000
roost	753	1.661	0.777	9.987	0.000
yacht	730	1.955	0.362	0.000	0.000
weigh	644	28.872	49.204	115.240	0.000
false	638	28.293	0.000	0.751	0.256
teach	599	35.323	21.685	183.095	0.000
globe	640	33.912	1.611	3.059	0.012
quick	597	70.048	6.442	205.321	0.274
bread	635	77.095	0.137	1.359	1.355
dread	736	4.325	3.641	8.687	0.008
weird	640	4.572	0.000	0.012	0.000
detect	771	4.042	3.891	14.412	0.000
pardon	712	4.016	0.463	0.022	0.000
cosmos	826	0.342	0.000	2.144	0.000
phylum	1085	0.335	0.020	0.000	0.255
sudden	648	38.281	0.000	168.060	0.000
effort	700	39.060	20.491	0.829	0.000
beauty	610	60.441	1.937	192.147	0.000
plenty	618	55.702	0.011	9.097	0.000
govern	735	4.871	9.424	191.505	0.000
random	635	4.971	0.000	0.000	0.000
explode	713	2.018	7.239	22.855	0.000
lacquer	893	2.038	0.237	0.023	0.000
success	632	43.750	1.900	97.549	0.000
balance	647	44.129	13.934	0.058	0.019
probable	810	4.481	0.000	215.260	0.000
adequate	758	4.576	0.000	3.261	0.000
slow	632	68.991	27.432	208.899	0.000
loud	628	69.119	20.007	25.053	0.015
chat	700	1.258	0.996	14.351	1.246
plop	832	1.224	0.487	0.041	0.000
pride	646	24.144	0.195	82.346	0.046
thumb	634	25.584	2.380	1.435	0.008
exact	665	40.034	0.296	120.466	0.000
sorry	648	39.704	0.000	11.843	0.000
guilt	663	1.365	0.000	7.140	0.000
steed	799	1.496	0.114	0.000	0.000
grace	655	11.989	0.608	16.555	0.187
trout	672	7.239	0.000	0.000	0.000
fright	684	9.803	0.011	63.925	0.000
priest	700	9.776	9.563	0.401	0.315
nature	638	83.010	5.341	171.358	0.000
cotton	687	80.731	0.150	5.319	0.000
critic	802	1.472	4.812	16.619	0.000
faucet	715	1.475	0.537	0.000	0.000
prompt	669	1.472	0.973	9.141	0.000
corpse	743	1.823	0.402	0.021	0.000
relate	672	5.581	66.389	121.207	0.000
cradle	698	5.991	1.381	0.096	0.000
educate	690	1.463	13.205	56.592	0.000
qualify	656	1.580	2.644	2.711	0.000
possess	797	5.482	9.147	31.205	0.000
harpoon	800	5.787	0.387	0.117	0.000
fortune	611	17.934	3.921	39.871	0.104
slender	674	14.338	0.291	0.000	0.000