THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 2004, *57A* (4), 745–765

Morphological decomposition and the reverse base frequency effect

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If recognition of a polymorphemic word always takes place via its decomposition into stem and affix, then the higher the frequency of its stem (i.e., base frequency) the easier the lexical decision response should be when frequency of the word itself (i.e., surface frequency) is controlled. Past experiments have demonstrated such a base frequency effect, but not under all circumstances. Thus, a dual pathway notion has become dominant as an account of morphological processing whereby both decomposition and whole-word access is possible. Two experiments are reported here that demonstrate how an obligatory decomposition account can handle the absence of base frequency effects. In particular, it is shown that the later stage of recombining the stem and affix is harder for high base frequency words than for lower base frequency words when matched on surface frequency, and that this can counterbalance the advantage of easier access to the higher frequency stem. When the combination stage is crucial for discriminating the word items from the nonword items, a reverse base frequency effect emerges, revealing the disadvantage at this stage for high base frequency words. Such an effect is hard for the dual-pathway account to explain, but follows naturally from the idea of obligatory decomposition.

All proficient English speakers know that *reheating* is a word. This does not mean, however, that such a polymorphemic word is recognized by matching it to a representation of the whole word in lexical memory. It is alternatively possible that it is decomposed into its individual morphemes (prefix *re*, stem *heat*, affix *ing*) and is recognized via the representation of its stem. Readers are certainly capable of such decomposition because they are able to work out what a novel word like *regrilling* must mean. So, the important question is whether morphological decomposition is a strategy reserved only for those situations where whole-word access fails (as with novel words), or whether it is the standard method of recognizing polymorphemic words, at least for transparently affixed words. The research to be presented here examines this question.

One notable means of determining whether the stem of a polymorphemic word is involved in the recognition of that word is to see whether ease of recognition is influenced by frequency

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The research reported in this paper was funded by a grant to the author by the Australian Research Council. The assistance of Marielle Lange is gratefully acknowledged.

http://www.tandf.co.uk/journals/pp/02724987.html DOI:10.1080/02724980343000477

of use of the stem (e.g., Baayen, Dijkstra, & Schreuder, 1997; Bertram, Schreuder, & Baayen, 2000; Bradley, 1979; Burani & Caramazza, 1987; Burani, Salmaso, & Caramazza, 1984; Colé, Beauvillain, & Segui, 1989; Schreuder & Baayen, 1997; Taft, 1979). Take, for example, the words *seeming* and *mending*. These two words have the same frequency of occurrence (i.e., a matched "surface" frequency), but the stem of the former is more frequently used than the stem of the latter; that is, *seem*, *seemed*, *seems*, and *seeming* occur cumulatively more often than *mend*, *mended*, *mends*, and *mending*. So, their "base" frequency is different. It has been shown that for many types of word, those with a high base frequency are associated with faster lexical decision times and/or fewer errors than those with a low base frequency (e.g., *seeming* being easier than *mending*). Such a base frequency effect implies that the polymorphemic word is decomposed into its component morphemes and is recognized via its stem. Indeed, from his original demonstration of the base frequency effect, Taft (1979) took the strongest position and proposed that morphological decomposition is an obligatory process that happens at the early stages of processing. Figure 1 illustrates this idea of obligatory morphological decomposition using the activation framework proposed by Taft (1994), with the addition of a lemma level of representation as proposed by Schreuder and Baayen (1995).

The lemma level contains units that provide the link between functional features (i.e., semantic and syntactic features) and the representation of form (i.e., orthography and phonology) and includes representations for both free and bound morphemes (see Taft, 2003). It can be seen in Figure 1 that a polymorphemic word that is entirely transparent with respect to its constituents (e.g., an inflected word like *seeming* or *mending*) does not possess its own lemma. This is because all functional information about that word can be generated entirely from its constituents (cf. Pinker, 1991). The dotted arrow leading from the form unit for *ing* is supposed to imply neutrality about whether there is also an independent lemma representing the inflectional affix, but to indicate nevertheless that information about the syntactic function of *ing* is activated somewhere in the system (perhaps in a separate syntactic module).

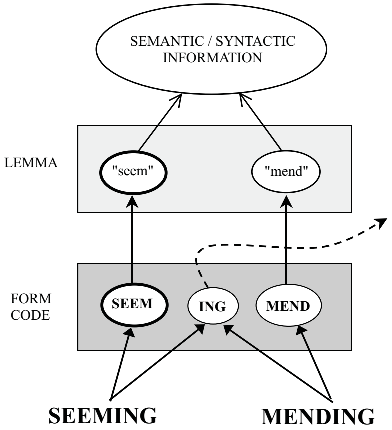

Figure 1. A schematic depiction of obligatory decomposition where the words *seeming* and *mending* are both recognized via activation of an input representation for their stem.

Note that an affixed word whose function cannot be entirely predicted from its morphemic constituents would need to be represented at the lemma level. For example, *feathery* is associated with specific information that cannot be determined purely from the meaning of its stem *feather* and its suffix *y* (e.g., that it refers to "lightness" more than to "feather-like shape"), and therefore a lemma is required for the whole word *feathery* in order to provide a link to that specific semantic information. This, however, does not necessitate the existence of a form-level representation for the whole word, as it is possible for the lemma of *feathery* to be activated via the form representations for its individual morphemes (i.e., *feather* and *y*).

According to the model depicted in Figure 1, then, an affixed word, or certainly a transparently affixed word (e.g., *seeming*), must be decomposed at the outset because there is no form representation for the whole word. Ultimately, though, the whole word is understood when the functional information associated with the lemma for its stem (i.e., *seem*) is combined with the syntactic information associated with its affix (i.e., *ing*).

Such obligatory decomposition handles the base frequency effect very easily. The more often a unit is used, the more readily it will be activated, and, as indicated by the thickness of the circles in Figure 1, both the form unit and the lemma unit for *seem* are used more often than the form unit and lemma unit for *mend*. So, responses to *seeming* will be easier to make than those to *mending* because of the stronger activation at the form level, the lemma level, or both.

Just because recognition is affected by base frequency in this manner, it does not follow that whole-word frequency is therefore irrelevant. At the final stage, when the stem and affix are recombined, there is the opportunity for surface frequency effects to emerge. Such an argument was made by Taft (1979) on finding that lexical decision responses were slower to words of relatively low surface frequency (e.g., *seeming*) than to words of relatively high surface frequency (e.g., *growing*), when matched on base frequency (i.e., the cumulative frequency of *seem*, *seemed*, *seems*, and *seeming* is approximately the same as that of *grow*, *grown, grew*,[1] *grows*, and *growing*). This surface frequency effect is explained in terms of the ease with which the information associated with the stem (*seem* vs. *grow*) can be combined with the information associated with the affix (*ing*). That is, *seem* is a stative verb that rarely takes a continuous aspect, whereas *grow* is a dynamic verb whose meaning is highly compatible with continuity over time, and, therefore, the former is harder to integrate with the syntactic function of *ing* than is the latter.

The idea that base frequency effects arise at an early stage of processing while surface frequency effects arise at a late stage derives support from studies examining eye movement research. Beauvillain (1996) found that the duration of first fixation on a suffixed (French) word was influenced by base frequency and not surface frequency, whereas the total amount of further fixation was influenced by surface frequency. In other words, the higher the base frequency, the less the time spent processing the first part of the word (i.e., the stem), while the higher the surface frequency, the less the time spent processing the word further. This is exactly the pattern expected if base frequency influences access to the lemma in the first place, with surface frequency influencing the ease with which the accessed stem information can be

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[1] Calculation here of cumulative frequency includes irregular affixed forms (like *grew*) because it could be argued (e.g., Allen & Badecker, 1999) that such forms share a lemma with the other members of their morphological family, even if not a form-level representation.

combined with the accessed affix information. A similar finding on fixation durations in English was obtained by Niswander, Pollatsek, and Rayner (2000), though the results were clearer with derivationally suffixed words than with inflectionally affixed words.

Despite the fact that the obligatory decomposition account is able to handle the existence of both base and surface frequency effects, alternative explanations have been put forward whereby the initial processing of a word is in terms of its whole undecomposed form. An example of this approach is the augmented addressed morphology (AAM) model (e.g., Burani & Caramazza, 1987; Burani & Laudanna, 1992; Caramazza, Laudanna, & Romani, 1988), illustrated in Figure 2. Here the polymorphemic word has its own form-level representation whose activation subsequently allows access to the relevant morphemic representations. Surface frequency effects arise at this early stage of processing (e.g., *growing* will be activated more readily than *seeming*) while base frequency effects arise from the higher level (morphemic) information, though there are two possible ways in which this can work.

The first possibility is that there is feedback to the word unit from the morpheme level such that the activation of the word unit is a function not only of the word's surface frequency, but of all other words that share the same morpheme (e.g., Burani & Caramazza, 1987). So effects of surface frequency emerge at the word level when base frequency is held constant, while effects of base frequency emerge at the same level when surface frequency is held constant.

The second potential source for base frequency effects is the morpheme level itself. That is, the polymorphemic word is ultimately recognized through its constituent morphemes, and, therefore, the frequency of usage of the stem morpheme will have an impact on the ease of recognition at this stage (e.g., *seem* will be activated more readily than *mend*). Thus, morphemic effects occur at a level above the whole-word level. A similar "supralexical" account is given by Giraudo and Grainger (2000).

One problem with a supralexical account of morphemic representation, however, is the fact that readers are sensitive to the morphological structure of nonwords. For example, bound morphemes are difficult to classify as nonwords both when presented in isolation (e.g., the *vive* of *revive* and *survive*: Taft, 1994; Taft & Forster, 1975) and when presented in combination with an inappropriate affix (e.g., *invive*: Taft & Forster, 1975; Taft, Hambly, & Kinoshita, 1986). If the only way to access a morphemic representation is via the unit representing the

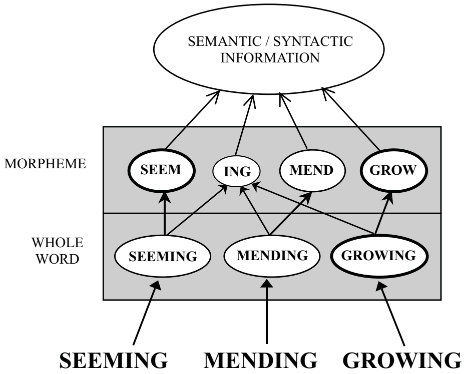

Figure 2. A schematic depiction of a supralexical decompositional system where the words *seeming*, *mending*, and *growing* are all recognized via activation of a whole-word representation prior to activation of their stem.

polymorphemic word that contains it, then it should not be possible to access morphemic information when the presented letter-string is not a word. To handle this situation, it is necessary to propose that the morpheme units can be accessed directly if no word-level representation exists, and this is indeed part of the AAM account (Burani & Caramazza, 1987; Caramazza et al., 1988).

The idea that there can be both direct activation of whole-word units and direct activation of morphemic units leads to the possibility that both of these activation pathways work in parallel and that the whole-word route is successful for some words while the decompositional route is successful for others (Baayen et al., 1997; Bertram et al., 2000; Schreuder & Baayen, 1995). Support for this position comes from studies that show only base frequency effects for some words and only surface frequency effects for others (e.g., Bertram, Laine, & Karvinen, 1999; Bertram et al., 2000). Indeed, the existence of base frequency effects has been taken to be a diagnostic of the use of a decomposition pathway while the existence of surface frequency effects has been taken to be a diagnostic of whole-word access (e.g., Baayen et al., 1997; Bertram et al., 1999, 2000; Niswander et al., 2000; Schreuder & Baayen, 1995).

Clearly, it is an attractive option to say that the presence of surface frequency effects in the absence of base frequency effects must mean that morphological decomposition has not taken place, and such a result is certainly an important challenge to the obligatory decomposition model depicted in Figure 1. However, while it is true that obligatory decomposition must produce differential activation in units representing stems of different frequencies, it is possible that any base frequency effect is obscured by counterbalancing influences at a later stage of processing. That is, while others have also supported the existence of a late stage where stem and affix are recombined (e.g., Schreuder & Baayen, 1995), it is not necessary to assume that such a process functions with the same ease for all words. To clarify this argument, consider the three situations in which it is possible for two affixed words to be matched on their surface frequency while being varied on their base frequency.

1. Sometimes a high base frequency (HB) word has a relatively low surface frequency because it is an affixed form of an unusual part of speech for the stem. For example, *timed* has a much higher base frequency than *raged*, but they are matched on surface frequency. The reason they are matched on surface frequency is that *time* is rarely used as a verb. Given that lemmas are the link between form and function, the different parts of speech of a word will be represented by different lemmas linked to the same form units, so there will be a separate lemma for the noun and verb versions of both *time* and *rage*. The verb lemma for *time*, however, will be far weaker than the noun lemma for *time* because of its lower frequency, whereas the verb lemma for *rage* will not have the same disadvantage relative to its noun lemma. What this means is that, while the form representation for *time* might be activated more readily than the form representation for *rage*, the verb lemma for *time* suffers from greater competition than does that for *rage*. That is, the functional information that is most strongly activated when *timed* is presented will suggest that *time* is a noun, which, therefore, cannot take the past tense. Such competition with the verb version has the potential to wash out the base frequency advantage. Indeed, Niswander et al. (2000) show that the duration of first fixation on an inflected word is predicted by the relative frequency with which the stem of that word is used in its particular syntactic category. In other words, duration of fixation on

timed is influenced by the fact that the use of *time* as a verb is much less common than its use as a noun.

Note that the interlemma competition suggested above might not only eliminate base frequency effects, but could potentially generate apparent surface frequency effects as well. This point can be illustrated with examples taken from the materials used by Niswander et al. (2000), who observed putative surface frequency effects for inflected words on first-fixation duration. In order to match pairs on base frequency while varying surface frequency, Niswander et al. used a number of cases where the stem of the low surface frequency (LS) word belonged to a relatively unlikely syntactic category. For example, *blinded* was used as an LS word, where the adjective version of *blind* is much more common than the verb version. What this means is that any difficulty in processing *blinded* could have arisen from the fact that the adjective lemma for *blind* was more strongly activated than the verb lemma for *blind*. Therefore, the putative surface frequency effect supposedly reflecting the low frequency of *blinded* as a word could actually have been a base frequency effect reflecting the low frequency of *blind* as a verb. The experiments by Taft (1979) are also open to this interpretation because the frequency manipulations in that study often capitalized on the use of the stem in its unusual syntactic category (e.g., *sized*).

It is apparent, then, that studies aimed at detecting base and surface frequency effects need to use manipulations that do not depend on the syntactic ambiguity of the stem, because the observed pattern of frequency effects will be hard to interpret. For this reason, such a manipulation of base frequency was avoided in the present research.

2. It is possible for an HB word to have a relatively low surface frequency without it having a syntactically ambiguous stem. In particular, there are HB words whose stem simply does not lend itself readily to the functional information associated with its suffix. Take the example of *moons* and *cliffs*. These words are matched on surface frequency by virtue of the fact that the stem *moon* typically refers to a single entity and therefore rarely takes the plural form (unlike the less common stem *cliff*). The competition here does not arise at the lemma level, but rather at the combination stage. That is, even though the lemma for *moon* will be activated more readily than the lemma for *cliff* (because of their different base frequencies), the decision that *moon* can be pluralized takes relatively longer than the same decision for *cliff*. Thus, depending on how much weight is placed on this decision stage, it would be possible to lose the base frequency advantage of *moons* over *cliffs*. The same is true for *seeming* relative to *mending*, where the decision that the stative verb *seem* can take a progressive inflection (i.e., *ing*) is harder than the same decision about the dynamic verb *mend*.

3. The final way in which two words could be matched on surface frequency while being varied on base frequency is where the LB word has a stem that rarely exists on its own. So, *fangs* (LB) is the same surface frequency as *slots*, but the former has a lower base frequency by virtue of the rarity of the stem *fang*. Again, the greater ease of activating the lemma for *slot* compared to the lemma for *fang* might be overcome by the greater ease of establishing that the latter can take the plural form. That is, the functional information associated with *fang* strongly suggests that it takes the plural, whereas the information associated with *slot* does not favour the plural over the singular.

The suggestion being made, then, is that the advantage at the early stages of processing of having a relatively high base frequency could be potentially obscured by counterbalancing factors happening at later stages of processing. The decision that the affix combines with the stem does not simply add a constant amount to the time taken to access the representation for the stem. Instead, words of higher base frequency are disadvantaged at this later stage relative to words of lower base frequency when they are matched on surface frequency. This means that whether base frequency effects are observed in an experiment will be influenced by processing at the combination stage.

The question then arises as to whether such an account is able to explain previous results that have failed to find a base frequency effect. No attempt will be made here to give a specific account for each of these results, but two of the more challenging studies will be singled out to indicate the sort of arguments that can be made. Consider the finding of Bertram et al. (2000) that Dutch words ending in the suffix *-er* only show a surface frequency effect. The suffix *-er* is ambiguous in that it can be used both as a comparative inflection on adjectives and an agentive derivation on verbs (just as it can in English), and no base frequency effect was found in either of its uses. From this finding, it was concluded that the existence of an ambiguous suffix leads to whole-word storage only. It is possible, however, to explain this result in terms of obligatory decomposition by arguing that the ambiguity of the suffix leads to greater difficulties for the higher base frequency words at the combination stage. The two functions of *-er* will both be activated at this late stage, so there will be competition between them when combining the suffix with the stem. If the particular stem is relatively rarely combined with *-er* (because it is either a common verb that does not lend itself to an agentive form or a common adjective that does not lend itself to a comparative form), then the combination stage will require more time, thus giving a greater opportunity for the competition between the two functions of the affix to have an effect. In this way, the greater competition for the HB words at the combination stage counteracts their base frequency advantage.

A second example comes from Sereno and Jongman (1997) who failed to find a base frequency[2] effect for singular nouns. For example, *mile* is matched on surface frequency to *desk*, and lexical decision times did not differ despite the fact that the former has a higher base frequency than the latter (because *miles* is more frequent than *desks*). To explain this lack of a base frequency effect, the obligatory decomposition account would need to say that there is a combination decision required even for nonaffixed words. In particular, there is difficulty in deciding whether an HB word (e.g., *mile*) can stand as a singular noun, arising from the heavy competition it receives from the more common plural function associated with its lemma, and this counterbalances the access advantage arising from its relatively high base frequency.

However, the result that is most puzzling in the Sereno and Jongman (1997) study is the fact that, while the HB plural (e.g., *miles*) was faster than the LB plural (e.g., *desks*), this difference was very weak (only 11 ms). According to the obligatory decomposition account, the advantage for HB words should have been considerable because not only was their base frequency greater than that for the LB words, but so was their surface frequency. In fact, the weakness of the effect is a problem for the alternative account as well, which claims that such words are stored and accessed as whole words. The difference in surface frequency values for the two conditions was very large, and, therefore, the higher surface frequency words (e.g.,

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[2] Sereno and Jongman (1997) referred to this as “total frequency”, reserving the term “base frequency” for the frequency of the stem by itself.

miles) should have shown a strong advantage over the lower surface frequency words (e.g., *desks*) if whole-word activation was involved. So, it may be that the two sets of words (i.e., the HB items like *mile* and *miles* and the LB items like *desk* and *desks*) did not happen to be well matched on factors other than stem frequency. For example, the HB words had more syllables on average and may have been more abstract in meaning than the LB words. Note that, if the weakness of the surface frequency effect for the plural forms is explained in terms of the HB plural nouns being relatively more difficult to recognize than would have been expected from their frequency, the same argument could be used to explain why the stems of those same words showed no sign of a base frequency advantage when presented in their singular form.

So, the argument being developed here is that it is premature to reject the obligatory decomposition account simply because base frequency effects are not always observed. Difficulties experienced at the combination stage for HB words can potentially explain the lack of a base frequency effect. The experiments to be reported here aim to demonstrate the role of the combination stage by manipulating the amount of weight that need be placed on it. That is, the less the need to consider the combinability of the stem and affix, the greater the impact of the earlier input stage and hence the greater the likelihood of observing base frequency effects. Conversely, the greater the need to consider the combinability of the affix and stem, the weaker the base frequency effect should be. Indeed, a reverse base frequency effect would even be possible should the disadvantage for HB words at the combination stage outweigh their advantage at the lemma access stage.

In order to manipulate the relative weight given to the combination stage, the type of nonword distractors used in a lexical decision experiment was varied. The logic behind this manipulation was as follows. If it is possible to discriminate word items from nonword items at the level of the stem, then there need be little emphasis placed on the combination stage. For example, if all the words in an experiment were inflected (e.g., *moons*, *mending*, *greatest*), and all the nonwords were inflected nonsense stems (e.g., *milphs*, *kossled*, *juxing*), then discrimination between the words and nonwords could rely largely on the success of activation of a lemma. The combination stage might still be involved in making the response, but relatively little weight need be placed on it, since merely reaching that stage would provide an indication that the item was a real word. As a result, a base frequency effect would be expected (e.g., *seeming* being easier to recognize than *mending*) because of differential lemma access with only a small counterbalancing effect at the combination stage. Moreover, a surface frequency effect might also be observed (e.g., *growing* being easier to recognize than *seeming*) because of the differential ease of recombining the stem and affix. The effect should be small, though, because of the relatively weak contribution of the combination stage to the response decision.

In contrast, if all the nonwords in such an experiment were replaced with ones that had a real word stem, then the only way that the word items could be discriminated from the nonword items would be through a detailed analysis at the combination stage. Examples of nonwords with real word stems are *mirths*, *kettled*, and *joying*. If there is obligatory decomposition, items like this can be classified as nonwords only by establishing that their accessed stem does not successfully combine with their suffix, and, therefore, greater attention must be given to the information associated with the lemma regarding the combinability of the stem and suffix. Because the ease of making the combinability decision is harder for a word whose surface frequency is low relative to its base frequency (e.g., *seeming*), not only should there be a large surface frequency effect (e.g., *growing* being easier to recognize than *seeming*), but the base frequency advantage should be counteracted, even possibly to the extent of becoming a disadvantage (e.g., *seeming* being harder to recognize than *mending*).

In contrast to these predictions, if an affixed word were recognized via whole-word access, the nature of the nonwords should have no impact. The existence, for example, of a representation for the whole suffixed word *seeming* would allow recognition of this word regardless of whether the nonword distractors activated representations for their stems or not. On the other hand, if decomposition and whole-word access were both available as an option for any particular word (e.g., *seeming*), then making the decomposition procedure difficult is exactly the situation in which whole-word access should take over. If so, a base frequency effect would be found when the nonwords have nonword stems (e.g., *milphs*), but this effect would be eliminated when the nonwords had word stems (e.g., *mirths*). What would be difficult to explain, however, is if the base frequency effect reversed under these circumstances. A reverse base frequency effect can only be explained in terms of special difficulties arising for HB words at the combination stage, and this entails prior decomposition.

To examine the possibility that the existence of base frequency effects is influenced by the importance of combinability information, the following experiments made use of suffixed words whose relationship to their stem was entirely transparent (which means that the suffixes were all inflectional, apart from the derivational adverbial suffix *ly*). The nature of the nonword distractors was manipulated so that one group of participants received affixed nonwords that always had a nonword as its stem (e.g., *milphs*), while another group received affixed nonwords that always had a word as its stem (e.g., *mirths*).

Two ways of manipulating base frequency were examined, and these will be treated as two separate experiments. However, for practical reasons, these two sets of words were actually presented together within the same experimental session.

EXPERIMENT 1

In Experiment 1, there was a manipulation of both base and surface frequency achieved explicitly by using words with a low surface frequency but a high base frequency (LS/HB), for which the function of their affix was unusual in relation to the functional information associated with their stem (e.g., *seeming*, *moons*). In other words, the percentage ratio of surface frequency to base frequency for these words was extremely low (2.2% on average). The base frequency effect was examined by comparing these items to other words that were matched on surface frequency, but were not as high on base frequency (e.g., *mending*, *cliffs*). Thus, these medium base frequency (i.e., LS/MB) words had a higher surface to base frequency ratio than did the LS/HB words (25.1% on average).

The effect of surface frequency was examined by comparing the LS/HB words (i.e., *seeming*, *moons*, etc.) to other words that were matched on base frequency, but were higher on surface frequency (e.g., *growing*, *boats*). The surface/base frequency ratio for these HS/HB items was similar to that of the LS/MB items (21.6% on average).

The participants were divided between two groups, where each group received a different set of nonword distractors. For one group, the nonwords always had a nonexistent stem (e.g., *milphs*, *juxing*), while for the other group, the nonwords always had a real word stem (e.g., *mirths*, *joying*).

According to the obligatory decomposition account, an effect of base frequency and possibly surface frequency should be observed when the nonwords have nonexistent stems. When the nonwords have real word stems, however, the surface frequency effect should be strong and the base frequency effect should disappear, even to the extent that it might reverse. According to the alternative dual-pathway account, the whole-word pathway should be used when the distractors have real word stems, and, therefore, disappearance of the base frequency effect would also be predicted. However, no reversal of this effect should occur.

Method

Materials

There were three real word conditions with 16 items in each condition. Table 1 presents the mean frequency values for each condition where it can be seen that there was a manipulation of both base frequency and surface frequency. All frequencies were determined from the norms of Carroll, Davies, and Richman (1971), with the matching confirmed on the basis of two other norms; Kučera and Francis (1967) and Baayen, Piepenbrock, and van Rijn (1993). The low surface/high base frequency word was always an unusual affixed form for its stem (e.g., *seeming*) and never capitalized on a syntactic ambiguity in the stem (i.e., words like *timed* were not used as items).

For the base frequency manipulation, the HB words were matched one-to-one on the affix used and on surface frequency with a set of MB words (e.g., *mending*). The former had a very low surface/base frequency ratio, the average being 2.2% with all items below 5%. The latter had an average surface/base frequency ratio of 25.1% with a range of 8.5%[3] up to 46.8%. The surface frequency manipulation compared the LS/HB words (e.g., *seeming*) to a set of words that were matched one-to-one both on the affix used and on base frequency, but had a higher surface frequency (HS). The average surface/base frequency ratio for these HS/HB words was 21.6% with a range of 9.3% up to 54.6%. Matched items, possessing the same affix, were always of the same grammatical class and, as a result, had virtually the same number of words sharing their stem.

In addition to the 48 experimental items, there were another 32 transparently suffixed words (that comprised the items of Experiment 2) along with 60 nonwords that were suffixed in the same way as the

TABLE 1
Mean frequency values[a] and length[b] for the three conditions tested in Experiment 1

	LS/MB *e.g., mending*		*LS/HB* *e.g., seeming*		*HS/HB* *e.g., growing*	
	M	*SD*	*M*	*SD*	*M*	*SD*
Surface frequency	7.8	10.74	7.7	10.60	75.9	66.55
Base frequency	36.5	46.17	460.3	413.26	456.9	448.14
Length	6.7		6.3		6.6	

[a] Per million, according to Carroll, Davies, and Richman (1971).
[b] No. of letters.
B = Base frequency, S = Surface frequency, H = High frequency, M = Medium frequency, L = Low frequency.

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[3] The few MB words with surface/base frequency ratios below 10%, were paired with HB words whose ratios were below 1.5%.

words. For one group of participants ($n = 18$), the nonwords were all cases where the removal of the suffix produced a stem that was not a word in its own right (e.g., *milphs*, *kossled*, *juxing*, *rinly*, and *ilodest*). In contrast, the second group ($n = 21$) were presented with nonwords that were all cases where the removal of the suffix produced a real word (e.g., *mirths*, *kettled*, *joying*, *redly*, and *iratest*). These real word stems had an average frequency of 106 per million (according to Carroll et al., 1971), with a third being under 15 per million and a third being over 75 per million. While arguments might be made that some of these nonwords can really be used as words (e.g., *musics*, *wristing*, *frictions*), the important point is that the reader is forced to consider the combinability of the stem and affix of all items.

All of the words and nonwords are presented in the Appendix.

Procedure

The 140 items were presented in a different random order to each participant, preceded by the same 12 practice items, where the nonwords corresponded to the type of nonword used in the actual experiment. Participants were told that they would see a series of letter-strings on the screen and were instructed to classify each of these as an existing word or nonexisting word as quickly but as accurately as possible. Responses were made by pressing a “yes” or “no” button. Each item was presented under computer control in lower-case letters on a television monitor for 500 ms with an intertrial interval of 1 s after the response.

Participants

The 39 participants were all first-year psychology students studying at the University of New South Wales, who were given course credit for their participation.

Results and discussion

After any response over 2000 ms was eliminated, cutoff values for each subject were calculated for response times as two standard deviations above or below the mean across all correct “yes” responses. Any responses falling outside of the cutoff values were replaced by the relevant cutoff value.

Mean lexical decision times and error rates are found in Table 2. The base frequency manipulation (LS/HB vs. LS/MB) was tested separately from the surface frequency manipulation (LS/HB vs. HS/HB). Each used a 2 × 2 analysis of variance (ANOVA) with the factors being relative frequency (higher vs. lower) and type of nonword distractor (nonsense vs. real stem). In the analysis by participants (F_1), relative frequency was a within-group factor, and nonword type was a between-groups factor. In the analysis by items (F_2), both factors were within-group factors, thus taking advantage of the pairwise matching of stimuli.

Turning first to the base frequency manipulation, there was a main effect of nonword distractor on both reaction time (RT), $F_1(1, 37) = 36.13, p < .001$; $F_2(1, 15) = 306.62, p < .001$, and error rate, $F_1(1, 37) = 23.34, p < .001$; $F_2(1, 15) = 19.19, p < .001$, reflecting the greater difficulty in discriminating the words from the nonwords when the latter had real word stems. The main effect of frequency was not significant on RTs, both Fs < 1, but reached significance on error rate, at least in the participant analysis, $F_1(1, 37) = 6.05, p < .05$; $F_2(1, 15) = 4.12, p < .1$, with more errors being made on the LS/HB items than the LS/MB items. Importantly, this reverse base frequency effect arose entirely from the group whose nonwords had real word stems (e.g., *mirths*). This is seen in the highly significant interaction on error rates between

TABLE 2
Mean reaction times[a] averaged across items and error rates[b] for the three conditions tested in Experiment 1

		LS/MB *e.g., mending*		*LS/HB* *e.g., seeming*		*HS/HB* *e.g., growing*		*Base freq. effect*	*Surface freq. effect*
		M	*SD*	*M*	*SD*	*M*	*SD*		
Distractors with nonsense stems (e.g., *milphs*)	RT	521	28.3	506	31.3	488	34.4	15	18
	Error rate	5.6	4.6	1.3	3.1	1.9	3.3	4.3	–0.6
Distractors with real word stems (e.g., *mirths*)	RT	687	69.8	701	80.2	653	63.9	–14	58
	Error rate	7.9	6.2	20.9	17.5	5.6	6.7	–13.0	15.3

[a] RT, in ms.
[b] In percentages.
B = Base frequency, S = Surface frequency, H = High frequency, M = Medium frequency, L = Low frequency.
Base freq. effect = LS/MB – LS/HB, Surface freq. effect = LS/HB – HS/HB.

frequency and distractor environment, $F_1(1, 37) = 33.32, p < .001$; $F_2(1, 15) = 17.02, p < .001$. There was a standard base frequency effect observed for the nonsense stem environment (e.g., *milphs*), with the HB words producing fewer errors than the LB words, $F_1(1, 17) = 10.25, p < .01$; $F_2(1, 15) = 8.01, p < .02$, but this effect dramatically reversed when the distractors were real word stems, $F_1(1, 17) = 26.37, p < .001$; $F_2(1, 15) = 10.71, p < .01$.

Reaction times showed the same pattern as the error rates, but the interaction was not significant, $F_1(1, 37) = 1.94, p > .1$; $F_2(1, 15) = 1.20, p > .1$. However, given the huge error rate on the LS/HB condition, the reaction time measure must be viewed as being quite unreliable, with the possibility of slower responders making relatively more errors in this difficult condition and, therefore, not contributing their long RTs.

So, it is shown that when the discrimination between the word and nonword items is made easy, LS/HB items (e.g., *seeming*, *moons*) are easier to classify as words than are well-matched LS/MB items (e.g., *mending*, *cliffs*), at least statistically so in terms of error rates. What is most striking about the results, however, is that when the decision about the combinability of stem and suffix is made difficult, the LS/HB items are more strongly affected than the LS/MB items, so much so that they actually become significantly harder to classify as words. Such a reverse base frequency effect demonstrates that the combining process is proportionally more difficult for higher base frequency words than lower base frequency words when matched on surface frequency. Therefore, although the easy word-nonword discrimination task shows that a high base frequency stem is easier to activate than a medium base frequency stem, this advantage can be counterbalanced, and indeed outweighed, by the relative disadvantage that arises when the combinability of stem and suffix is considered in depth by the reader.

In relation to the surface frequency effect, the main effect of distractor was again significant, $F_1(1, 37) = 32.11, p < .001$; $F_2(1, 15) = 248.49, p < .001$ for latencies, and $F_1(1, 37) = 20.02, p < .001$; $F_2(1, 15) = 25.40, p < .001$ for error rates. The main effect of frequency was also significant on both RTs, $F_1(1, 37) = 13.61, p < .001$; $F_2(1, 15) = 4.56, p < .05$, and error rate, $F_1(1, 37) = 44.62, p < .001$; $F_2(1, 15) = 6.80, p < .05$, with the HS/HB words being easier than the LS/HB words. As with the base frequency effect, there was an interaction between frequency and nonword type on error rates only, with a larger surface frequency effect for the word stem distractors: $F_1(1, 37) = 45.16$, $p < .001$; $F_2(1, 15) = 11.34$, $p < .01$ for error rates, and $F_1(1, 37) = 1.73$, $p > .1$; $F_2(1, 15) < 1$ for RTs. When analysing error rates for the two nonword environments separately, a significant surface frequency effect was found when the distractors had word stems, $F_1(1, 17) = 59.48$, $p < .001$; $F_2(1, 15) = 9.04$, $p < .01$, but not when they had nonsense stems, both *F*s < 1.

It can be seen, then, that when combinability information is important (i.e., when nonword distractors have real word stems), a surface frequency effect clearly emerges in the error data, as opposed to when the words can be readily distinguished from the nonwords (i.e., when the nonwords have nonsense stems). This suggests that the surface frequency effect emanates from the late combination stage rather than from early whole-word access. However, the fact that reaction times showed a significant main effect of surface frequency that did not significantly interact with distractor type implies that the combination stage is always reached regardless of the nonword environment, even if the error data suggests that little emphasis is placed on it when the words can be readily distinguished from the nonwords. Again, though, it must be noted that the lack of a significant interaction between frequency and distractor type on RTs could have arisen from the unreliability of reaction time data when the error rate is exceptionally high (as was the case with the LS/HB words in the environment of nonwords with real word stems).

Finally, the mean reaction time to the nonsense stem distractors themselves (e.g., *milphs*) was 601 ms with an error rate of 10.6%, while the mean reaction time to the word stem distractors (e.g., *mirths*) was 824 ms with an error rate as high as 35.6%. It is apparent that combinability decisions are often hard to make when the nonword has a real word stem. Indeed, for 15 of these 60 nonword distractors, there were more than 50% "word" responses given, including *sheeps*, *frictions*, *furnitures*, *sweeped*, and *joying*.

The cases of *sheeps* and *sweeped* are particularly interesting because their stems can respectively take the plural (i.e., *sheep*) and past tense (i.e., *swept*), but not in the regular form as presented. Thus, functional information alone will suggest that the stem can combine with the affix, and an error will occur. In order to know that *sheeps* and *sweeped* do not actually exist, there needs to be specific information stored that marks them as exceptions, and this information must pertain to the formal structure of the word. The implication is, therefore, that information about form is also potentially available at the higher levels of processing, though presumably only when it is idiosyncratic.

EXPERIMENT 2

As pointed out earlier, there are three ways in which frequency can be manipulated to test for a base frequency effect. The first of these was considered unsatisfactory due to ambiguity of interpretation, namely, when capitalizing on an unusual syntactic function for the stem (e.g., *timed*). Experiment 1 made use of the second type of manipulation by comparing LS/HB words (e.g., *seeming*, *moons*) to LS/MB words (e.g., *mending*, *cliffs*), where the former was an unusual form in relation to the meaning of the stem. In Experiment 2, the third type of base frequency manipulation was examined. This time, LS/MB words (e.g., *slots*) constituted the higher frequency group, with a comparison being made to LS/LB words. This latter type of word is one where the inflected form of the word is the most frequent use of the stem, hence contributing most of the base frequency. For example, the stem *fang* is mostly found in its plural form, so that the LS/LB word *fangs* has a base frequency that is not very different from its surface frequency.

The purpose of examining this type of manipulation (i.e., LS/MB vs. LS/LB) is to confirm the decision-based explanation for the reverse base frequency effect in Experiment 1. In particular, there is no reason to expect a reverse base frequency effect when there are no LS/HB words involved. That is, the reverse base frequency effect should only arise when the activated stem rarely takes on the function suggested by the affix, as with LS/HB words like *moons*. The combinability decision might be easier for an LS/LB word (e.g., *fangs*) than for an LS/MB word (e.g., *slots*) because the use of the suffix is relatively more compatible with the function of the stem of the former than with that of the latter. However, this advantage for the LB words over the MB words is unlikely to overcompensate for the disadvantage of having to access the functional information through a relatively low base frequency stem (e.g., *fang* vs. *slot*). That is, there is unlikely to be a reverse base frequency effect when the combinability information facilitates the recognition of lower base frequency words (i.e., LS/LB words like *fangs*) than when it inhibits the recognition of higher base frequency words (i.e., LS/HB words like *moons*). There is a lower limit to the amount of facilitation that can occur, whereas inhibition is not so constrained. It is, therefore, predicted that LS/MB words will be easier to recognize than LS/LB words when the nonword distractors have nonsense stems (e.g., *milphs*), but that this difference will diminish when the nonword distractors have real word stems (e.g., *mirths*). However, it is unlikely to diminish to the extent that a reverse effect is found (i.e., where the low base frequency words become easier to recognize than the medium base frequency words).

Method

Materials

The manipulation of base frequency involved a comparison of 16 low base frequency words with 16 medium base frequency words. The words of each condition were matched one-to-one both on the affix used and on surface frequency, which was low on average (see Table 3). The low base frequency words (LS/LB) were all cases where the stem rarely occurs as a word in its own right (e.g., *fangs*). This meant that the average ratio of surface frequency to base frequency was very high, namely, 79.6% (with all items above 50%). The medium base frequency words (LS/MB) were different from the LS/MB words used in Experiment 1, though their average surface/base frequency ratio was very similar, being 22.1% (with a range of 7.5% up to 43.1%[4]). For example, *slots* has a stem that occurs reasonably often by itself, in fact rather more often than *slots* itself. The matched pairs were of the same grammatical class.

Procedure and participants

Because the 32 words were included amongst the items used in Experiment 1, the procedure and participants were the same.

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[4] The few MB words with surface/base frequency ratios above 30% were paired with LB words whose ratios were above 80%.

TABLE 3
Mean frequency values[a] and length[b] for the two conditions tested in Experiment 2

	LS/LB *e.g., fangs*		*LS/MB* *e.g., slots*	
	M	*SD*	*M*	*SD*
Surface frequency	9.8	12.17	9.9	12.49
Base frequency	14.7	19.37	53.9	64.51
Length	6.9		6.9	

[a] Per million, according to Carroll, Davies, and Richman (1971).
[b] No. of letters.
B = Base frequency, S = Surface frequency, M = Medium frequency, L = Low frequency.

Results and discussion

The data were treated in the same way as in Experiment 1. The mean RTs and error rates are presented in Table 4.

As in Experiment 1, the type of distractor had an impact on both RTs, $F_1(1, 37) = 35.61$, $p < .001$; $F_2(1, 15) = 305.70$, $p < .001$, and error rate, $F_1(1, 37) = 23.12$, $p < .001$; $F_2(1, 15) = 19.72$, $p < .001$. However, the main effect of base frequency proved to be nonsignificant on both the RT measure, $F_1(1, 37) = 2.69$, $p > .05$; $F_2(1, 15) = 2.48$, $p > .05$, and the accuracy measure, $F_1(1, 37) = 1.85$, $p > .05$; $F_2(1, 15) = 2.38$, $p > .05$. There was no interaction between distractor type and frequency, with all Fs < 1.46.

It is seen in these data that, when using low base frequency words whose base frequency comes primarily from their inflected form (e.g., *fangs*), the base frequency effect is very weak. It might simply be argued that base frequency has no impact when manipulated in this way. However, it should be noted that, if only the nonsense stem environment had been examined, a different conclusion would have been reached, because the base frequency manipulation was

TABLE 4
Mean reaction times[a] averaged across items and error rates[b] for the two conditions tested in Experiment 2

		LS/LB *e.g., fangs*		*LS/MB* *e.g., slots*		*Base freq. effect*
		M	*SD*	*M*	*SD*	
Distractors with nonsense stems	RT	527	32.5	502	37.0	25
(e.g., *milphs*)	ER	5.3	5.9	2.2	2.6	3.1
Distractors with real word stems	RT	701	56.1	692	66.4	9
(e.g., *mirths*)	ER	11.4	9.5	9.5	7.4	1.9

[a] RT, in ms.
[b] In percentages.
B = Base frequency, S = Surface frequency, H = High frequency, M = Medium frequency, L = Low frequency.
Base freq. effect = LS/MB – LS/HB, Surface freq. effect = LS/HB – HS/HB.

actually significant for this distractor type on the RT measure, $F_1(1, 17) = 14.12, p < .01$; $F_2(1, 15) = 11.24, p < .01$, as well as on the accuracy measure, at least in the item analysis, $F_1(1, 17) = 2.00, p > .05$; $F_2(1, 15) = 5.81, p < .05$. It may well be that the real stem distractors reduced the size of the base frequency effect to the extent that the frequency factor was not significant when the two distractor groups were analysed together, but not to the extent that a significant interaction with distractor group emerged. Most importantly, though, and in stark contrast to Experiment 1, there was no sign of a reverse base frequency effect when the discrimination between the words and nonwords was made harder by the inclusion of nonwords with real word stems. The contrast between experiments is borne out statistically when an analysis of the base frequency effect is carried out across the two experiments.

Combining Experiments 1 and 2

A 2 × 2 × 2 ANOVA was carried out with the factors being distractor type (nonsense stems vs. real word stems), base frequency (higher vs. lower), and type of base frequency manipulation (LS/HB vs. LS/LB, each relative to LS/MB). The last factor was a within-group manipulation in the participant analysis (because the same individuals participated in the two experiments), but a between-group manipulation in the item analysis.

On error rates, there was no main effect of base frequency, $F_1(1, 37) = 1.07, p > .05$; $F_2 < 1$, but there was a clear interaction between base frequency and type of manipulation, $F_1(1, 37) = 8.85, p < .01$; $F_2(1, 30) = 6.49, p < .05$, as well as between base frequency and type of distractor, $F_1(1, 37) = 16.26, p < .001$; $F_2(1, 30) = 11.69, p < .01$. Most importantly, there was also a three-way interaction, $F_1(1, 37) = 10.65, p < .01$; $F_2(1, 30) = 8.87, p < .01$, demonstrating that while the presence of real stem distractors altered the base frequency effect, it had a bigger impact on the manipulation of Experiment 1 than on the manipulation of Experiment 2.

When the nonwords had nonsense stems (e.g., *milphs*), the analysis of error rates when combining Experiments 1 and 2 showed a main effect of base frequency (with higher base frequency producing fewer errors than lower base frequency), $F_1(1, 17) = 8.05, p < .01$; $F_2(1, 30) = 13.82, p < .001$, and no interaction with type of base frequency manipulation, both Fs < 1. In contrast, when the nonwords had real word stems (e.g., *mirths*), the main effect of base frequency was significant in the reverse direction, $F_1(1, 20) = 9.33, p < .01$; $F_2(1, 30) = 4.84, p < .05$, but more importantly, there was a strong interaction between this base frequency effect and the type of base frequency manipulation, $F_1(1, 20) = 13.36, p < .01$; $F_2(1, 30) = 8.82, p < .01$.

Such a result supports the interpretation given for the impact on responses of nonword distractors that have real word stems. The impact comes from an increased need to focus on the combinability of the stem and affix, and when they rarely do combine (as with *seeming* and *moons*), classification as a word becomes very difficult. In contrast, when the stem typically combines with its presented affix (as with *fangs*) there is facilitation relative to a case where the combination of stem and affix is less likely (as with *slots*). Thus, the advantage of activating the higher base frequency stem (i.e., the lemma for *slot* being activated more readily than the lemma for *fang*) is counterbalanced, but not outweighed, by the relative facilitation afforded to the lower base frequency word (i.e., the decision that *fang* can take *-s* being more obvious than the same decision about *slot*).

Finally, the combined analysis showed no main effects or interactions on the reaction time measure (with the highest *F* value being 2.39). As noted previously, however, the mean RT for the LS/HB items in the real stem nonword environment is likely to be unreliable owing to the very high error rate. In this respect, it is worth noting that when the RT analysis did not include this error-prone condition—namely, when looking only at the nonsense stem environment—there was a significant base frequency effect on reaction times, $F_1(1, 17) = 11.02$, $p < .01$; $F_2(1, 15) = 11.48$, $p < .01$, with no interaction between this effect and the type of manipulation, both *F*s < 1. Thus, even on the latency measure, there is some evidence to suggest that higher base frequency words are easier to recognize than lower base frequency words when matched on surface frequency when the decision about the combinability of stem and affix is undemanding.

GENERAL DISCUSSION

The results obtained in this study have important implications for models of polymorphemic word recognition. First, it is apparent that the lack of a base frequency effect does not in itself constitute evidence against morphological decomposition. The fact that processing at the combination stage is shown to work against high base frequency words with relatively low surface frequency means that the emergence of base frequency effects depends on how much weight the participant places on the combination stage. In other words, the existence of a surface frequency effect with a concomitant lack of a base frequency effect need not imply that whole-word access has taken place without decomposition. It may simply be that the advantage of activating a high frequency base word at decomposition is counteracted by the disadvantage encountered at the later combination stage.

Second, the reverse base frequency effect observed in Experiment 1 can only be explained in terms of decomposition. According to the alternative AAM account depicted in Figure 2, for example, base frequency effects arise either from activation of whole-word representations that are influenced by base frequency, or directly from the supralexical activation of stem representations. The former explanation can be readily dispensed with, however, because it assumes a "hardwiring" of base frequency into the whole-word units, and, therefore, the base frequency effect cannot be modified by different task strategies as shown in the present study. The latter "supralexical" explanation cannot parsimoniously handle the reverse base frequency effect either. According to this account, a whole-word representation exists in addition to representations of the individual morphemes and, therefore, should be used when morpheme-mediated recognition is made difficult. For example, if *moons* has a whole-word representation, but *mirths* does not, why not discriminate between them at the level of the whole word? The reverse base frequency effect attests to the fact that a postdecomposition recombination stage cannot be circumvented simply by falling back on whole-word recognition. So, the results are incompatible with any dual-pathway account that supposes that there is parallel activation of representations for the whole inflected word and for its component morphemes.

A version of the dual-pathway account can be maintained, however, if one assumes that some types of word use morphemic decomposition exclusively (i.e., obligatory decomposition), while other types use whole-word access exclusively, and that the present study simply used the types of affix that engage the decomposition pathway. It seems that this all-or-none position has only been previously proposed in order to contrast suffixed words and prefixed words (Colé et al., 1989) or inflected words and derived words (Niemi, Laine, & Tuominen, 1994). However, the position of Bertram et al. (2000) could also potentially be given an all-or-none interpretation whereby the type of affix does more than simply bias the weighting given to one of the parallel pathways. Rather, it might determine which pathway is exclusively engaged. As it happens, though, the types of affix used in the present study actually correspond more with one of the conditions that are claimed by Bertram et al. (2000) to promote whole-word processing. In particular, the productive affixes used in the present study mostly had an ambiguous function, yet this is one of the factors that is supposedly unfavourable to decomposition. For example, *-s* can represent both a plural noun inflection (e.g., "some *moves*") and a third-person singular verb inflection (e.g., "it *moves*"), *-ing* can represent both a progressive verb inflection (e.g., "is *meeting*") and a nominal derivation (e.g., "a *meeting*"), and *-ly* can be used to derive an adverb from an adjective (e.g., *sadly*) or an adjective from a noun (e.g., *scholarly*). The alternative account given earlier for the Bertram et al. (2000) findings on affix ambiguity ascribed the loss of the base frequency effect to factors arising at the recombination stage. Base frequency had an effect in the present experiment when the nonwords had nonsense stems, yet showed no effect in the context of similar nonwords in the Bertram et al. (2000) study. To explain this discrepancy within an obligatory decomposition account, it might be argued that the combination stage is more important in Dutch than in English. In relation to the dual-pathway account, the present study indicates that, at the very least, the factors that have been claimed to be important in determining whether or not decomposition occurs cannot be attributed to all languages.

Beyond that, though, once one concedes that base frequency effects can be lost even for words that require decomposition, then one is accepting that the absence of a base frequency effect does not demand whole-word access. Yet it is the absence of base frequency effects (with a concomitant surface frequency effect) that has been standardly used to support the existence of whole-word access. It is true, however, that the absence of base frequency effects in the Bertram et al. (2000) study arose under the optimal conditions for finding base frequency effects—namely, when the nonwords had nonsense stems (equivalent to *milphs*)—and this needs to be handled by the obligatory decomposition account. The position would, therefore, be that the types of word that show no base frequency effect are simply those for which the combination stage is particularly important, and that, therefore, there is more opportunity for the counterbalancing influence of that stage to have an impact. Perhaps there are differences between languages regarding the importance of the combination stage, with that stage being more important for languages that have a more productive morphology.

So, the obligatory decomposition view offers a straightforward account for the pattern of base frequency effects observed in the present study. Decomposition always occurs and always at the input stage of processing. Base frequency effects emerge at that stage. Surface frequency has its impact at the subsequent combination stage, and difficulties arising at this stage can serve to counteract the base frequency effect. By using nonwords that had real word stems, the combination process was made as difficult as possible, thus giving an opportunity to demonstrate this counteracting effect by making it so great that it more than counterbalanced the base frequency effect.[5]

Even if an alternative explanation for the obtained pattern of results can be given, the important point being made here is that the absence of a base frequency effect should not be taken to mean that decomposition has not taken place. Instead, it might suggest that the circumstances under which the words were presented, or the type of word examined, may have led the participants to place enough weight on the combination stage such that any base frequency effects were obscured.

It must be emphasized that the present conclusions can only be drawn about affixed words that can be understood entirely from the combination of the functions of both their stem and their affix. As was mentioned earlier, when it comes to other affixed words (e.g., *feathery*), there has to be a whole-word representation somewhere in the system that allows word-specific information to become available. However, even in these cases, it is possible that decomposition is obligatory. In particular, it may be that the word is decomposed and that there are then two pathways to the full information about the word: recombination via functional information associated with its individual constituents, and activation of a precompiled whole-word representation via the constituents. In this way, there would be two parallel pathways, but rather than these being a whole-word and a decomposition route, they would be a whole-word and a recombination route. Of course, such a position is totally speculative at this point and awaits empirical examination.

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[5] Given that the average base frequency of the words contained in the nonwords with real word stems was lower than that of the high base frequency words, but not lower than that of the low and medium base frequency words, an argument might be mounted that the results can simply be explained in terms of a strategy adopted in relation to the HB words based on their distinctively high frequency. Such a strategy would have to be one whereby there was a bias to say “no” to any item whose stem was of high frequency relative to the average of the nonwords, and that such a bias had no impact when the surface form was also high. Apart from the post hoc nature of such an account (e.g., why the bias would be toward saying “no” rather than “yes”, and why the mean stem frequency of the nonwords would be taken into account when the frequencies spanned such a wide range), the error rates for the nonwords are not supportive. If there were a bias toward saying “no” when the stem is of high frequency, nonwords with higher frequency stems should have been correctly rejected more often than those with lower frequency stems. However, the correlation between stem frequency and error rate showed only a negligible trend in this direction, $r(60) = -.11$. In fact, the correlation between stem frequency and RT was significant in the reverse direction, $r(60) = .26$, suggesting that rejection of a nonword was harder when its stem was of higher frequency. Why this should have been so is unclear, but there is certainly little support for an explanation based on a frequency discrimination between the words and nonwords.

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Original manuscript received 16 May 2002
Accepted revision received 4 March 2003

APPENDIX

Words used in Experiments 1A and 1B

MB	HB	HB
LS	LS	LS
mending	seeming	growing
twisting	wanting	turning
cliffs	moons	boats
debts	worlds	nights
veils	soups	sharks
timidly	hotly	widely
partners	winters	forests
poking	proving	smiling
grimly	poorly	badly
slightest	newest	greatest
trends	truths	depths
forks	threes	homes
sells	hears	moves
sleeping	knowing	looking
artists	fathers	questions
attending	believing	containing

Words used in Experiments 2A and 2B

LB	MB
LS	LS
fangs	slots
sardines	cavities
trousers	beaches
scissors	mirrors
incurred	ignited
invited	belonged
scarcely	commonly
freckles	fashions
ribs	bricks
gills	crews
obliged	rejoiced
genes	queens
shining	speaking
germs	ponds
compelled	resisted
blurted	fetched

Nonwords used in Experiments 1A and 2A

thouds, borlies, sniefs, rinly, fosely, yaining, girped, racored, fardocing, istenked, sebs, chavishly, somins, swoiked, chonds, hedded, staiping, ilodest, hoarning, emistidities, plucties, ozypars, felmigures, dolps, fubs, selgarest, juxing, trobed, swaffenks, giorkly, mibocs, woyed, spoathing, milphs, miped, wrulbing, thilded, glofing, froches, hoirths, insluanjas, bivly, dauglest, flurging, stawpattis, kossled, vimbing, cetaked, olbenly, floibing, cuggles, pamared, pluzes, fazzies, peching, chozzes, hupps, flentions, goisly, mofs.

Nonwords used in Experiments 1B and 2B

trouts, barleys, sheeps, redly, fively, yearing, golded, rivering, fortuning, islanded, sads, claimly, satins, sweeped, childs, hitted, stouting, iratest, hearting, electricities, plenties, oxygens, furnitures, damps, funs, silverest, joying, tribed, swimmings, giantly, musics, buyed, speeching, mirths, maked, wristing, thefted, graping, freshes, healths, influenzas, bigly, doublest, fridging, spaghettis, kettled, vasting, cigared, oftenly, frailing, cattles, palaced, proses, fuzzies, pathing, chesses, wools, frictions, gainly, muds.