The combinatorial lexicon: Priming derivational affixes

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Abstract

In earlier research we argued for a morphemically decomposed account of the mental representation of semantically transparent derived forms, such as *happiness*, *rebuild*, and *punishment*. We proposed that such forms were represented as stems linked to derivational affixes, as in {happy} + {-ness} or {re-} + {build}. A major source of evidence for this was the pattern of priming effects, between derived forms and their stems, in a cross-modal repetition priming task. In two new experiments we investigated the prediction of this account that derivational affixes, such as {-ness} or {re-}, should also exist as independent entities in the mental lexicon, and should also be primable. We tested both prefixes and suffixes, split into productive and unproductive groups (where "unproductive" means no longer used to form new words), and found significant priming effects in the same cross-modal task. These effects were strongest for the productive suffixes and prefixes, as in prime-target pairs such as *darkness/toughness* and *rearrange/rethink*, where the overall effects were as strong as those for derived/stem pairs such as *absurdity/absurd*, and where possible phonological effects are ruled out by the absence of priming in phonological control and pseudo-affix conditions. We interpret this as evidence for a combinatorial approach to lexical representation.

Introduction

In previous papers delivered to this society, and elsewhere, we have argued for a morphological approach to the mental lexicon (e.g., Marslen-Wilson, Tyler, Waksler, & Older, 1992; 1994). In particular, we have argued that morphologically complex words in English, such as *happiness*, *disconnect*, *breakable*, etc., are mentally represented as two or more morphemes - *happy + ness*, *dis + connect*, *break + able* - rather than as single units. The research we report here takes this work a significant step further, showing priming between derivational affixes. This is strong evidence not only for the *combinatorial* nature of the mental computations underlying lexical representation and processing, but also for the truly *morphological* - and not simply semantic - nature of the effects we are dealing with.

We will begin by outlining our basic claims about the properties of lexical representations, summarising the kinds of evidence and the experimental techniques involved in establishing these claims. The first point to make clear is that what we are talking about is the properties of the *lexical entry* - of the modality-independent central representation of a word's semantic, syntactic, and morphological properties. We distinguish this from any modality-specific *access representations* involved in the initial mapping from speech or text onto the lexical entry.

We are concerned, then, with these core structures of the mental lexicon. To ensure that this is the level that we are tapping into experimentally, we have mainly used a *cross-modal repetition priming* task (which we also use in the experiments reported here). This is a task where subjects hear an auditorily presented prime word, and immediately at the offset of this word they see a visual target - a word or nonword to which they have to make a lexical decision.

The advantage of this task is that it allows us to tap directly into the state of representations at the level of the lexical entry. Cross-modal priming reflects repeated access to lexical representations shared by prime and target. The word *happiness*, for example, primes the word *happy* (relative to some control prime), because both prime and target have in common the morpheme {happy}. The activation of this morpheme, as a consequence of hearing the prime, speeds up subsequent recognition (and hence lexical decision) for the same morpheme when presented as a word on its own.

On the basis of several experiments looking at derivationally suffixed and prefixed words in English, we have argued for a morphologically decomposed mental lexicon. Specifically, we propose a model where morphologically complex forms are mentally represented in a {stem + affix} format. Each complex word is made up of a stem and one or more affixes. These stems are always free morphemes - that is, they can stand alone as individual words in English. For example, the morpheme {govern} functions in this framework both as a word on its own, and as a stem in forms like *government*, *misgovern*, *ungovernable*, and so on.

Crucially, this decomposed {stem + affix} arrangement only applies to semantically transparent derived forms. A word like *department*, for example, cannot be meaningfully decomposed into the stem *depart* plus the affix *-ment*, and must be represented at the level of the lexical entry as a simple form, without any internal structure, just as if it were a monomorphemic word.

Here we see an important contrast between *stored* lexical representations, which are in some sense *looked up*, because they already exist in the system as complete structures, as opposed to the representation of more transparent words, like *rebuild* or *lateness*. These, we argue, are not stored in the same way. Their meanings, and their grammatical properties, have to be computed as the word is heard or read, by combining the properties of the stem with the properties of the affix.

This is a strongly combinatorial view of lexical representation and processing, and it assigns a crucial role not just to the stem morphemes but also to the *affixes*; the derivational suffixes and prefixes in English which combine with stems to form new words, often with very different syntactic and semantic properties. Combining the affix {-ness} with the stem {dirty}, for example, converts an adjective into an abstract noun (*dirtiness*). Combining the affix {-er} with the stem {build}, converts a verb into a noun (*builder*), and so on.

These are powerful operations, and any morphologically based theory of lexical representation will have to have some way of accommodating them. But although linguistic accounts of morphology have had a lot to say about affixes, there has been very little experimental work on their mental representation. Psycholinguistic work, ours included, has been much more interested in the properties of stems. But until we understand more about affixes, and about how they fulfil their central role in lexical representation and processing, any theory of the mental lexicon will be incomplete; especially any theory arguing for a morphemically decomposed lexicon organised around combinatorial operations

As a first step in this direction, we address here the question of whether derivational affixes are independent entitities in the lexical system. The affixes we are dealing with are all *bound* morphemes. This means that they cannot, unlike free morphemes, stand alone as words in English. There is no word *ness*, corresponding to the *-ness* in *darkness*; there is no word *ment*, corresponding to the *-ment* in *punishment*; there is no word *re*, corresponding to the *re-* in *rebuild* or *reopen*. These are all bound morphemes that can only occur in conjunction with a stem. But does this also mean that they cannot stand alone as cognitive elements, represented separately from the stems to which they apply?

It follows from our decompositional approach to lexical representation that this should be the case; that affixes should be independently represented as morphemic elements. On a strongly combinatorial view, the *-ness* in *happiness* should be the same as the *-ness* in *darkness*; the *re-* in *refill* should be the same as the *re-* in *rebuild*, and so on. This predicts that we should be able to get priming between these forms. *Darkness* should prime *happiness*, in much the same way, and for the same reasons, as two forms sharing the same stem. If we do get priming, this would be a strong confirmation of the approach we have been developing

In contrast, on an approach where morphologically complex words are separately represented, so that *happiness* does not share a morpheme with *happy*, and where the *ness* in *happiness* is not the same processing entity as the *ness* in *darkness*, then there should be no priming between items which share the same affix. We report here two experiments designed to test these questions.

Experiment 1

The first goal of the experiment is to compare affix priming with stem priming. Will we get affix priming at all? Will it be comparable to typical stem priming effects?

In this first experiment we include the two major *affix types* in English: *suffixes* and *prefixes*. Suffixes in English, such as *-ment*, *-ness*, *-ation*, typically have major syntactic and semantic effects on their stems, converting them into quite different linguistic objects. English prefixes, such as *un-*, *re-*, *-dis*, typically have more restricted effects. They normally do not change syntactic class - *rebuild* is still a verb - but introduce notions such as negation or repetition, Where there is no *a priori* reason to expect priming results to vary as a function of affix type, it is still an important variable to keep controlled.

The second important factor is *affix productivity* - whether an affix is still being used in ordinary speech to form new words. This may well interact with possible priming effects. Productive affixes like *-ness* or *re-* are more likely to be independently represented - and therefore primable - than affixes like *en-* (as in *enslave*) or *-th* (as in *depth*) which are no longer productive in the language.

The design of the resulting cross-modal priming experiment (auditory primes, visual targets) is outlined in Table 1. The two variables of affix type and productivity give us 4 sets of 24 affixed prime-target pairs, with a further comparison set of 24 prime-target words sharing the same stems. All stimuli, whether primes or targets, were semantically transparent, as established on the basis of the appropriate pretests. Each related prime was paired with an unrelated control prime, matched in frequency and number of syllables, to provide a baseline for measuring possible priming effects.

Suffixes	**Prime**	**Target**
Productive	darkness	toughness
UnProductive	development	government
Prefixes		
Productive	rearrange	rethink
UnProductive	enslave	encircle
Stems	absurdity	absurd

Table 1. Experiment 1: Design and sample stimuli

The productive suffixes included affixes such as *-ation*, *ble*. and *-ness*, contrasting with nonproductive suffixes ch as *-ment*, *-al*, and *-ate*. Productive prefixes included -. *pre-*. and *dis-*, contrasting with unproductive prefixes ce *en-*. *in-*, and *mis-*.

The results, listed in Table 2, are straightforward. here is a significant priming for productive suffixes and efixes, and this is of the same order of magnitude as e effects obtained for the comparison group of stem iming stimuli. In contrast, effects are reduced for the nproductive affixes, with no significant effect for the iffixes, and only marginal effects for the prefixes. There , however, no overall statistical interaction between roductivity and priming effects; just the overall main fect of prime type ($F1[1,25] = 30.2$, $p<.001$; $F2[1,82] = 3.4$, $p<.001$).

Suffixes	Test	Control	Priming
Productive	569	596	27*
Unproductive	554	566	12
Prefixes			
Productive	566	597	31**
Unproductive	589	612	23(*)
Stems	533	563	30**

** p<.01, * p <.05, (*) p <.10

Table 2. Experiment 1: Lexical decision RTs (ms)

We take this to be strong preliminary evidence for the ndependent status in the lexical system not just of stems ut also of bound morphemes, such as the derivational ffixes tested here. This is, however, a result which needs o be replicated, not only to confirm the existence of affix riming, but also to exclude the possibility that the esults are due to the phonological overlap between prime nd target. Although cross-modal priming is a task where orm similarity has generally played little role in letermining priming effects, it is important to exclude his possibility for these types of stimulus.

Experiment 2

The second experiment included two new kinds of omparison, both designed to test for the possibility of honological effects (see Table 3 below). The first was a et of pseudo-affix conditions, where the same primes vere used as in the suffix and prefix experiments, but vhere the targets were now pseudo-affixed words like *lagger*, *carnation*, or *region*. If the reason that *swimmer* rimes *gambler* is because of phonological overlap in the ast syllable, then the same amount of priming should be ound for pairs like *swimmer* and *dagger*, which share xactly the same phonological material.

The second comparison controls directly for honological overlap, with pairs that overlap either word nitially (like *pilgrim/pilfer* or *vintage/vindicate*) or word inally (like *jacket/bucket* or *volcano/casino*), and where o potential morphological relations are involved. Again, if the priming effects in Experiment 1 can be reduced to, or are contributed to, by form similarities between prime and target, we should also see priming between stimuli of this type.

	Prime	Target
Suffixes		
Productive	darkness	toughness
Unproductive	adjustment	government
Prefixes		
Productive	rearrange	rewrite
Unproductive	misfire	misbehave
Pseudo-Suffixes		
Productive	darkness	harness
Unproductive	adjustment	garment
Pseudo-Prefixes		
Productive	rearrange	recent
Unproductive	misfire	mistress
Phonological Overlap		
Initial Overlap	vintage	vindicate
Final Overlap	puritan	charlatan
Stems	absurdity	absurd

Table 3. Experiment 2: Design and stimuli

Turning to the affixed prime/target pairs, these again were broken down by affix type and productivity, with these divisions mirrored in the design for the pseudo-affix sets (see Table 3). Each test prime was paired with an unrelated control prime, matched for frequency and number of syllables. There were 20 prime-target pairs in each condition (affixed, pseudo-affixed, phonological overlap, stem).

The cross-modal priming results, as summarised in Figures 1 and 2, are clear-cut, and comprehensively rule out any interpretation in terms of phonological relations between primes and targets. First, as shown in Figure 1, there is strong priming for productive suffixes and prefixes, averaging 31 msec, which again parallels the stem priming effects (24 msec). Priming for unproductive suffixes and prefixes, while still significant, is somewhat weaker, averaging 15 msec. This pattern generally replicates the findings for Experiment 1, with similar affix and stem effects.

Turning to the Pseudo-affix and Phonological Overlap conditions, none of these show any significant facilitation. The word-initial overlap condition (*vintage/vindicate*) in fact generates a significant interference effect of -32 msec. In the final overlap (*jacket/bucket*) condition there is a minor overall effect of -5 msec.

More importantly, the comparison between Affixed and Pseudo-affixed conditions not only rules out phonological effects, but also, as illustrated in Figure 2, clarifies the importance of affix productivity. Collapsing over affix type, since prefixes and suffixes behave similarly throughout, it is clear that there is little difference (averaging 8 msec) between Affixed and

Pseudo-affixed items when they involve Unproductive affixes. In contrast, there is a highly significant difference of 36 msec for the Productive items ($p<.01$), where the Affix stimuli show an increase in priming whereas the Pseudo-affix pairs show a tendency to interference, especially in the Pseudo-Suffix condition.

These effects are reflected in the interaction between Productivity, Target Type (Affix/Pseudo-affix), and Prime Type (Test/Control) in the analyses of variance conducted on these data. ($F1[1, 43] = 5.36$, $p = .03$; $F2[1, 124] = 3.19$, $p = .07$

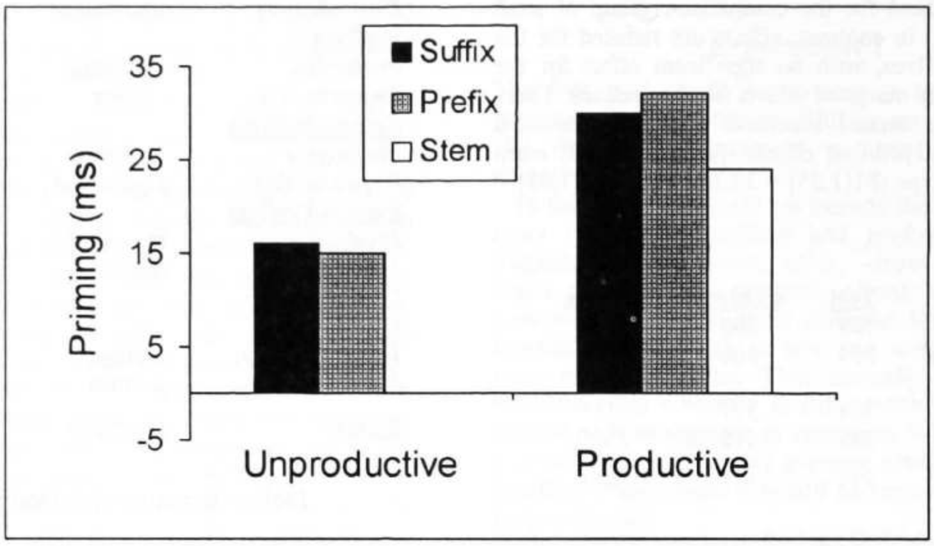

Figure 1: Priming effects for Suffixes, Prefixes, and Stems

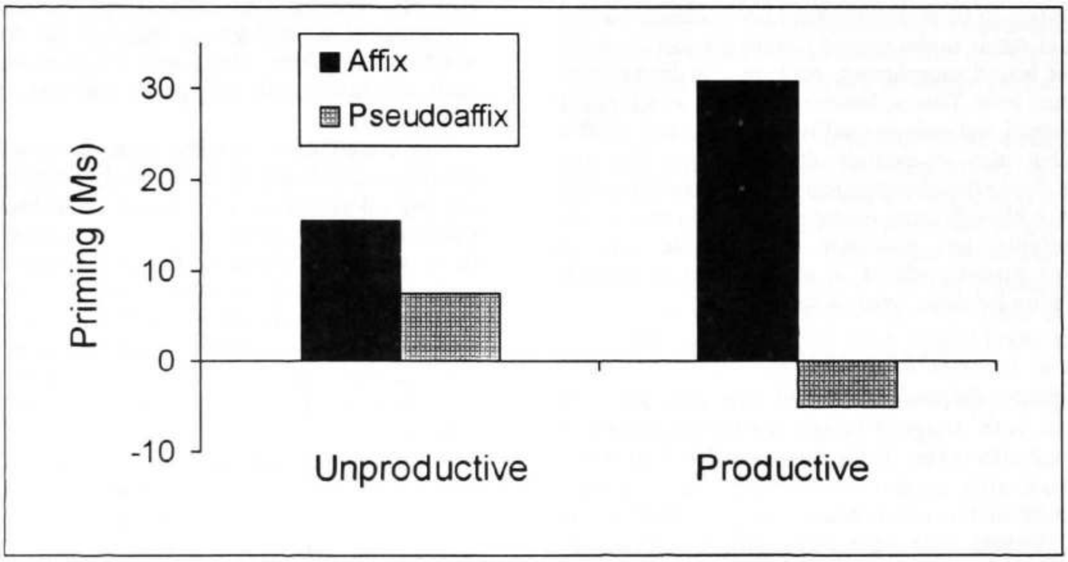

Figure 2: Productivity effects for Affixed and Pseudoaffixed stimulus pairs

Conclusions

The important result is that we have clear evidence that bound morphemes - English derivational affixes - are isolable and independent processing structures in the mental lexicon. We find priming across the board for prefixes and suffixes, under the same conditions and at the same level that we find priming between words sharing the same stem. It is hard to see how this can be explained except in terms of a strongly combinatorial, morphemically decomposed view of the mental lexicon, where the representation and access of morphologically complex forms involves computational processes that combine stems and affixes, and where both partners in these computations - free and bound morphemes - have underlyingly equal status as processing agents.

The picture is strengthened by the effects of productivity. Affix productivity is a gradient phenomenon, but nonetheless priming is consistently stronger for productive affixes like *-ness*, *re-* and *-able*. These are the affixes that are currently in productive use in forming new words in the language, and they could not perform this function, either for the speaker coining a new form or for the listener interpreting it, unless they had an independent cognitive status. As new words come into the language (like *microwaveable* and *downloadable* in the 1980's) their interpretability depends on the availability to the perceiver of the syntactic and semantic properties of the affix, and on the successful combination of these properties with those of the stem morpheme.

These are also results that are hard to explain on any simple semantic story, which seeks to explain priming between morphologically related words as a form of semantic priming, along the lines of the priming found between otherwise unrelated pairs like *cello* and *violin*. The bound morphemes that prime here do not have clearly definable semantic identities. They are fundamentally morphological entities, functioning in productive combinatorial linguistic processes, and it is unlikely that priming relations between them can be accounted for in terms which do not take into account their role as part of a linguistic, morphological system.

This is, finally, the beginning of a story rather than the end of one. Given their evident status as active components of lexical processing, how are these bound morphemes represented and processed in the language system? What is the basis of the priming effects we obtained - re-activation of the same structure, or repetition of the same cluster of processing procedures? And how are we to interpret these results under the assumption that the computational infrastructure for human language processing is distributed and sub-symbolic? How does a system of this type, exposed to the complex pattern of phonological and semantic regularities and irregularities in the language input, convert this into a form of internal representation with the morphological and combinatorial properties apparently exposed by the research here?

References

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