6 LEXICAL PROCESSING, MORPHOLOGICAL COMPLEXITY AND READING

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INTRODUCTION

One of the basic processes involved in reading is word recognition. This process is a very efficient one considering the fact that the normal reading rate is around five to eight words a second. This process involves looking up a word and retrieving the associated information in the very short time span of 125 - 200 ms. This is fast considering estimations of passive vocabulary size of approximately seventy thousand lemma's (Oldfield, 1963). The number of access representations could be dramatically higher if one would assume that every inflected form of such a lemma would have its own access representation. Thus, a theory of word recognition has to take into account the morphological status of access representations. Some aspects of this issue also have consequences, as we argue presently, for word recognition as it occurs during reading, that is, when word recognition takes place as part of processing a larger linguistic structure than the single word.

Questions about the role of morphology in word recognition can be summarized as follows (Henderson, 1985):

1. To what extent are words decomposed into their constituent morphemes prior to lexical access? (e.g., Taft & Forster, 1975).

2. Does the mental lexicon contain separate lexical entries for morphological variants of words and for the constituent morphemes of compounds? (e.g., MacKay, 1978; Murrell & Morton, 1974).

3. Is there any evidence for the existence of morphological rules, and if so, what is their nature?

It is obvious that these questions are closely related. In this chapter, however, we focus on the second question. We attempt to shed some light on the problem of the mental representation of morphological variants. With respect to this issue, three main hypotheses have been distinguished.

One has been referred to as the full listing hypothesis (Butterworth, 1983). According to the full listing hypothesis words are stored in and retrieved from the mental lexicon as full forms. This implies that all the individual forms of a word have independent representations. Thus, *read*, *reader*, *reads* and *reread* each has a separate lexical entry.

The second hypothesis holds that words are represented in the lexicon only by their stems (or base forms) and that the full forms are to be derived by the application of morphological rules (see MacKay, 1978, for a related view). According to this hypothesis, the mental lexicon has independent lexical entries READ, -ER (meaning AGENT), -S (meaning THIRD PERSON SINGULAR PRESENT TENSE), and RE- (meaning DO AGAIN), plus some specifications as to which morphemes can be combined with each other.

The third (and weaker) hypothesis claims that both full forms and morphemes are listed in the lexicon (e.g., Caramazza, Laudanna, & Romani, 1988, the so-called augmented addressed morphology [AAM] model). Such models are in fact a combination of the first two types of models.

In this chapter, we present some data bearing on the role of inflectional and derivational morphological structures during word recognition. On the one hand, the experiments presented here test some aspects of the AAM model for inflected forms. However, these experiments also explore a particular subset of morphologically complex words that are of special interest for the process of word recognition during reading. These are complex verbs consisting of a particle (often a preposition or an adverb) and a verb such as *aan + vallen* 'attack' or *weg + lopen* 'walk away'. Both in Dutch and in German, the particle of these complex verbs can appear much later in the sentence than the accompanying verb parts, as can be seen in Example 2.

1. *De soldaten mogen niet aanvallen.*
   The soldiers are not allowed to attack.
2. *De soldaten vielen die nacht aan.*
   The soldiers attacked that night.

This introduces interesting problems for the processing system, to be argued later.

Before presenting a review of some of the crucial studies that have been conducted on the role of morphology in word recognition, we discuss briefly the distinction between inflectional and derivational morphology. Inflectional morphemes, such as the suffix *-s* in the English form *rereads*, are rule governed. These rules generally apply to all members of a grammatical class. As such, they are semantically predictable, which means that they do not radically change the meaning of the word stem to which they are added nor do they change its grammatical category. Derivational morphemes, on the other hand, can be used to express special meanings that are not reliably predictable from the meaning of the component morphemes. An example given by Henderson (1985) is the word pair *to generate–generation*. Although *generation* is clearly derived from *to generate*, the meaning of the stem is not the same in these two words, and there is a change in grammatical category. In contrast to inflectional morphemes, derivational morphemes combine with only a relatively small subset of words. Hence, derivational processes are not necessarily productive. Given the notion of predictability, one could assume that decomposition for inflected forms is more probable than decomposition for derived forms, because the meaning of a derived word is not always a simple function of the meaning of its parts. Or, in linguistic terminology, derived forms are not fully compositional whereas inflected forms are.

EMPIRICAL EVIDENCE FOR A DECOMPOSED LEXICON

Prefix Stripping

Much of the research on the internal representation of morphologically complex words was inspired by Taft and Forster's (1975) theory of prelexical morphological decomposition. Taft and Forster presented a model of word recognition which combined a decomposed lexicon with a prelexical decomposition process, and hence their model is relevant to the first two questions mentioned at the beginning of this chapter. Their model consists of several stages. In the first, possible affixes are detected and stripped off the word form. In the second, the lexicon is searched for an entry corresponding to the word stem. If this entry is not found, a search is started for the entry of the whole word. If, however, the entry for the stem is found, the next step is to check if stem plus affix form a word.

Taft and Forster's decomposition model predicts longer latencies in lexical decision tasks for pseudo-affixed words, such as *premium* and *sublime*, than for truly affixed words such as *subnormal*). In both cases, prelexical decomposition takes place, but in the case of a pseudo-affixed word, more tests are required to decide on its being a real word. This prediction was supported by the results of Taft and Forster's (1975) investigations, in which they utilized a lexical-decision task (see also Taft, 1981). Manelis and Tharp (1977), however, and Henderson, Wallis, and Knight (1984) failed to find evidence for morphological decomposition when (derivationally) suffixed rather than prefixed words were used. They found no differences in the lexical decision times for pseudosuffixed and truly suffixed words. Thus, there appears to be a difference between suffixes and prefixes.

In line with these last findings, Bergman, Hudson, and Eling (1988) obtained similar effects using Dutch words with pseudoprefixes, but not for Dutch words with pseudosuffixes. These authors argue for a model where the basic access representation is the stem. The prefix in this model is not stripped, but its access is a by-product of stem extraction.

Other investigators tested the prelexical decomposition model by means of a paradigm which exploits the fact that words are recognized more easily when they are presented for a second time (repetition priming). The interpretation of the (often conflicting) results obtained with repetition priming is not without problems, however. It is often claimed that evidence for the role of morphology in repetition priming arises due to morphological analyses performed *after* lexical access (e.g., Bergman, 1988, Henderson, 1985). That is, morphological structures might become available as a result of lexical access, without playing a role in the process of access itself. For this reason, we do not discuss this line of evidence here.

The AAM Model

Recently, Caramazza et al. (1988) investigated the issue of the level of morphological decomposition in the mental lexicon studying the Italian inflectional system for verbs. They assumed that a letter string activates both whole-word representations (for known word forms) as well as the morphemes that comprise a word. The stimulus *walked* will activate the access representations WALKED, WALK-, and -ED (as well as orthographically similar representations). Because the model stipulates that the whole word representations for known words will always reach their thresholds before the associated morpheme representations reach theirs, it is assumed that the decomposed access units only play a role when the letter string forms a word seen for the first time. In a number of lexical decision experiments, Caramazza et al. varied the morphological structure of nonword stimuli. The pattern of results was both inconsistent with a fully decomposed lexicon and with a lexicon of full forms only.

One problem with this study is that it crucially depends on pseudoword processing in a lexical-decision task. The reason for this is that the AAM model predicts that morphological complexity of existing word forms does *not* influence lexical access time as long as these word forms have an access representation. Caramazza et al. claimed that their model could only be tested by varying inflectional structures of pseudowords. Lexical-decision experiments, however, may encourage subjects to use special strategies (Balota & Chumbley, 1984). For this reason, such experiments may tap task-related rather than natural behavior. Furthermore, there is the question whether processing of non-words can give essential information about the processing of real words. Fortunately, there is a technique that allows one to test some of the properties of the AAM model while using existing words. This same technique can also be used for testing prefix stripping theories using a naming task rather than a lexical-decision task.

THE SHORT SOA PRIMING TASK

Inflection

Jarvella, Job, Sandström, and Schreuder (1987)[1] adopted a priming technique from Eriksen and Eriksen (1974) that avoids many of the problems just noted. They showed some of the letters of a word as a prime, while the remaining letters were momentarily withheld. After a very short SOA (30 to 60 ms), the remaining letters were filled in, making the whole word visible. In a nonpriming trial, the word was presented all at once. The idea behind this technique is that presenting some parts of the word first (e.g., the stem) will affect lexical access more than presenting other parts first.

The study by Jarvella et al. indicated that this method is potentially fruitful for studying the effects of morphological structure in early stages of lexical processing. Their results indicated that inflected verb forms in Italian had decomposed entries, whereas the Dutch verb forms seemed to have a full listing. The results are as yet inconclusive because precise controls in that study were lacking. The rationale for our using the task they employed to investigate the AAM model is as follows. Assume that a lexicon is organized as described by the AAM model and consider the Dutch verb form *helpt* (2nd and 3rd person singular, present tense; 'to help'). According to AAM the lexicon contains the entries HELPT, HELP-, and -T. We present the string *help* for 60 ms and then add the final *t*. Both HELPT and HELP- will become activated (presumably HELP- will get a higher activation). As, according to Caramazza et al., the phonological output lexicon is also organized in a morphologically decomposed form, both access representations will start to preactivate the phonological output representation HELP-. This then predicts that, if we present the form *help* with the final *t* presented 60 ms later, the naming latency for *helpt* will be faster than when we present *helpt* in the no-priming condition. The earlier studies of Jarvella et al. suggest that 60 ms is enough to trigger the access representation of a given form. However, controls are crucial to show that this is an effect of morphological information and is not caused by orthographic priming only. Therefore the same conditions will be used with a control noun like *helft* ('half') of the same length but without an internal morphological

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[1] The technique used in the experiments presented in this article was developed by Bob Jarvella and Remo Job.

structure. That is, *helf* is *not* a word stem like *help*. The AAM model predicts that the amount of priming should be larger when a string with morphemic status is given as a prime (*help* for the form *helpt*) than with a nonmorphemic prime (*helf* for the form *helft*).

Of course, a full listing theory does not predict a difference. We return to the issue of a fully decomposed lexicon in the discussion. A fully decomposed lexicon is, at least for a language like Dutch, on purely linguistic grounds very improbable, as we argue.

Because we used complex verbs of two morphemes, it is possible also to use the *second* morpheme as a prime. It is not clear what the AAM model would predict here, but again the full entry theory does not predict a difference between morphologically defined strings and strings that have no morphological status.

Derivationally Complex Words

Taft and Forster's (1975) prefix-stripping model and the left-to-right parsing model of Bergman (1988) and Bergman et al. (1988) both suggest that access of the prefix and access of the stem occur separately. It seems reasonable to assume that to present these parts asynchronously in time would be helpful in the identification of these substructures. Therefore, both models predict priming effects for the first morpheme used as a prime and for the second morpheme used as a prime. That is, in both cases a separation in time helps to identify the two components that have to be accessed separately.

MORPHOLOGICAL PROPERTIES OF THE MATERIALS USED

This study consisted of four different parts. In two of these, the experimental items were inflected verb forms, as in the experiments run by Caramazza et al. (1988). The other two parts involved verb forms with derivational prefixes and complex verbs with a separable, preposed particle. Here, we address the difference between separable and inseparable verb particles. The Dutch language distinguishes between verbs with separable derivational prefixes and verbs with separable particles, often prepositions or adverbs. In the case of separable particles the particle that is attached to the stem in the infinitive verb form (*aannemen*) is separated from the stem in the inflected verb forms. Consider the following examples:

3. *Zullen we dat cadeautje AANNEMEN?*
   (Shall we accept that present?)
4. *Ik NEEM dat cadeautje niet AAN.*
   (I do not accept that present.)

Inseparable prefixes are always attached to the stem, whether they occur in infinitive verb forms or inflected verb forms. This is illustrated in Examples 5 and 6.

5. *Je had dat feit moeten VERMELDEN.*
   (You should have mentioned that fact.)
6. *Ik VERMELD dat feit niet.*
   (I do not mention that fact.)

The reason to include verbs with separable particles is that they have the important property of generally being noncompositional. As an example consider the verb *vallen* ('to fall') in complex verbs with a preposition like *aanvallen* ('to attack'), *afvallen* ('to lose weight'), *omvallen* ('to fall over'), *invallen* ('to invade'). In these cases, knowing the meaning of the verb *vallen* and knowing the meaning of the preposition does not help much in predicting the meaning of the combination of the two. The noncompositionality of the verbs with a separable particle poses some interesting problems for lexical access during reading, because after having accessed *vallen* there can be a stretch of several words before the associated particle appears, for example, *aan*. But the meaning of the sentence cannot be computed on the basis of the separate entries of *aan* and *vallen* alone! Rather, these two have to be combined in some way so that the entry for their combination becomes available. That is, it seems as if the morphological structure of this type of complex verb has to be represented in some way in the lexicon. If we expect evidence for morphological structures in the access lexicon for Dutch verbs at all, we expect it in the case of these verbs. Neither the left-to-right parsing theory nor the prefix stripping theory make a distinction between different types of preposed particles, and thus both models predict the same amount of priming for the different types of verbs.

METHOD

Subjects

The subjects were 51 native speakers of Dutch, all students at the University of Nijmegen. They were paid for their participation.

Materials and Design

The words were selected from lists of potential stimuli that were generated from the CELEX data base (cf. Schreuder & Kerkman, 1987). This data base, which was constructed for linguistic research, contains lexical information for approximately 110,000 Dutch headwords (i.e., stems or lemmas). This is nearly exhaustive for the Dutch language.[2]

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[2] Because we posed many constraints on our materials, they are almost exhaustive for the Dutch language. That is, it would not be possible to run the same experiment again using other materials. For this reason, we did not compute statistics across materials. There are two possibilities to overcome the generalization problem in this case. One is that other experiments using other methods and/or designs should be run looking at the same issues. The other is to study other languages that have the same phenomenon. German is such a language. We are currently pursuing both approaches.

The four parts of the experiment were conducted in one combined design. There were two inflection and two derivation subexperiments. The stimuli for each part were different. Within each subexperiment the stimuli were divided into two equal groups of items: experimental items and control items.

For the first subexperiment, dealing with inflectional suffixes, 48 word pairs were found that fulfilled our requirements. The experimental items were verbs with the following inflectional endings: *-t* (2nd and 3rd person singular present tense) and *-te* (2nd and 3rd person singular past tense). The control items were nouns ending in noninflectional *-t* or *-te*. These nouns differed from the verbs in only one letter, as shown in Examples 7 and 8.

	Experimental		Control
7.	*beeft* 'trembles'	-	*beest* 'beast'
8.	*hoopte* 'hoped'	-	*hoogte* 'height'

The second part, dealing with inflectional prefixes, consisted of 39 word pairs. The experimental items were past participles, starting with *ge-*. The control items were nouns, also starting with *ge-*. Again the difference between the experimental and the control items was that the string *ge-* has a morphological status in the experimental items but not in the control items as shown in Examples 9 and 10.

9. *gelucht* 'aired' - *gehucht* 'hamlet'
10. *gerafeld* 'frayed' - *geranium* 'geranium'

In the third part, dealing with separable particles (again, 39 word pairs), the experimental items were verbs in the infinitive form beginning with one of the following separable particles: *uit-*, *aan-*, *toe-*, *op-*, *in-*, *af-*, *om-*. The control items were nouns beginning with one of these seven letter strings, but this time the letter strings did not function as prefixes, that is, they were pseudoprefixes, as shown in Examples 11 and 12.

11. *indrukken* 'press' - *industrie* 'industry'
12. *omkeren* 'turn round' - *omelet* 'omelet'

In the fourth subexperiment, dealing with derivational inseparable prefixes, 39 word pairs were used. Four inseparable prefixes occurred: *be-*, *ge-*, *ver-*, and *ont-*. The control items were nouns starting with the same letter strings, but, as in the second subexperiment, these strings did not function as prefixes but as pseudoprefixes as shown in Examples 13 and 14.

13. *betonen* 'show' - *begonia* 'begonia'
14. *verteren* 'digest' - *verkering* 'courtship'

All groups of experimental and control words were matched for frequency, number of syllables, word length, and stress pattern as far as possible in order to obtain comparable naming latencies in the baseline conditions. All items were presented in three conditions:

1. Without an SOA, that is, with all letters shown at once (the NO-PRIMING condition).
2. With the first morpheme, or the corresponding part of the control items, appearing 60 ms before the remainder of the word (the M1 condition, respectively C1 condition).
3. With the second morpheme, or the corresponding part of the control items, appearing 60 ms before the remainder of the word (the M2 condition, resp. C2 condition).

Each subject was presented with each item in only one of the three conditions. For each item, the three conditions were rotated across subjects. For each subject, the items of the four subexperiments were completely randomized.

Procedure

All subjects were tested individually. Their task was to name the stimuli as fast as possible. The words were displayed on a CRT screen attached to a BBC computer system. They were presented in lowercase letters of 3 mm height. The subjects were seated in front of the screen at a distance of approximately 30 cm. Each trial was preceded by a fixation point that appeared on the screen 600 ms before the stimulus was shown. The words disappeared as soon as the subjects vocalization triggered the voice key.

To familiarize the subjects with the procedure, a practice session consisting of 54 trials was run before the actual experiment. The stimuli in the practice session were representative of those used in the four subexperiments. Before the experimental session started, the subjects were given a short break. They were given another break during the experimental session when they had completed 200 of the 330 trials. Altogether, the session lasted approximately 35 minutes.

RESULTS

The naming latencies of incorrectly pronounced words were discarded from analysis, as were latencies outside the range of a subject's grand mean plus or minus two times the standard deviation for that subject. Nine subjects were excluded from analysis because their error percentage exceeded 5%. The rotation of materials across subjects was complete.

The mean naming latencies for the baseline condition (NO-PRIMING) of the different subparts are reported in Table 6.1. There was no difference between the experimental and the control items in the baseline conditions of the inflectional suffix, the separable particle, and inseparable prefix subexperiments: respectively $t(82) = 0.814$, $MSE = 175.66$, $t(82) = 1.379$, $MSE = 301.94$, and $t(82) = 0.820$, $MSE = 308.83$, $p > 0.05$. In the inflectional prefix part, however, the control items were named significantly faster than the experimental items ($t(82) = 5.532$, $MSE = 388.92$, $p < 0.05$).

TABLE 6.1

Mean Naming Latencies (ms) for the No-priming Condition of the Inflectional Suffix, Inflectional Prefix, Separable Particle, and Inseparable Prefix Parts.

	Experimental	*Control*
Inflectional Suffix	521	518
Inflectional Prefix	564	543
Separable Particle	505	510
Inseparable Prefix	538	534

For all parts of the experiment, a priori contrasts were carried out to test whether the amount of facilitation obtained by priming the target word by part of it differed between the experimental and the control items. The amount of facilitation is the difference between a priming condition (M1, M2, C1, C2) and its baseline condition (NO-PRIMING).

Means for the conditions of the inflectional suffix part are shown in Table 6.2. The M1 condition showed no difference in facilitation between the experimental and the control items ($t(82) = 1.22$, $MSE = 175.66$, $p > 0.05$). Also, the difference in facilitation between the experimental and the control items in the M2 condition failed to reach significance ($t < 1$). Thus, providing an inflectional suffix gave the same amount of priming as a nonmorphological control string.

Means for the conditions of the inflectional prefix part are presented in Table 6.3. The amount of priming was not significantly greater for the experimental items than for the control items in both the M1 condition and the M2 condition ($t < 1$). Again, there is no evidence for a morphological priming effect.

TABLE 6.2

Means for the Conditions of the Inflectional Suffix.[a]

	Experimental			*Control*		
	No-priming	*M1*	*M2*	*No-priming*	*C1*	*C2*
Example	*(hapte)*	*(hap)*	*(te)*	*(halte)*	*(hal)*	*(te)*
	521	474	523	518	476	517
		[47]	[–2]		[42]	[1]

[a] Mean naming latencies (ms) for the experimental and the control words without a prime (No-priming) or primed by either their first morpheme (M1) or the second morpheme (M2), or primed by a nonmorphemic string in the control conditions (C1 and C2, respectively). Square brackets indicate the amount of facilitation in ms.

TABLE 6.3

Means for the Conditions of the Inflectional Prefix.[a]

	Experimental			*Control*		
	No-priming	*M1*	*M2*	*No-priming*	*C1*	*C2*
Example	*(gewed)*	*(ge)*	*(wed)*	*(gewei)*	*(ge)*	*(wei)*
	564	539	543	543	519	527
		[25]	[21]		[24]	[16]

[a] Mean naming latencies (ms) for the experimental and the control words without a prime (No-priming) or primed by either their first morpheme (M1) or second morpheme (M2), or primed by a nonmorphemic string in the control conditions (C1 and C2, respectively). Square brackets indicate the amount of facilitation in ms.

Means for each condition of the derivational separable prefix part are presented in Table 6.4. The facilitation was significantly greater for the experimental items than for the control items in the M1 condition and in the M2 condition (respectively, $t(82) = 1.84$, $MSE = 308.83$, $p < 0.05$ and $t(82) = 4.98$, $p < 0.05$). For the experimental words, the M2 priming was significantly greater than the M1 priming ($t(82) = 3.008$, p

< 0.05). Thus, in this case it does appear that a morphological priming effect has been obtained.

TABLE 6.4

Means for the Conditions of the Derivational Separable Particle.[a]

	Experimental			Control		
	No-priming	*M1*	*M2*	*No-priming*	*C1*	*C2*
Example	*(inenten)*	*(in)*	*(enten)*	*(intentie)*	*(in)*	*(tentie)*
	505	479	467	510	494	499
		[26]	[38]		[16]	[11]

[a] Mean naming latencies (ms) for the experimental and the control words without a prime (No-priming) or primed by either their first morpheme (M1) or second morpheme (M2), or primed by a nonmorphemic string in the control conditions (C1 and C2, respectively). Square brackets indicate the amount of facilitation in ms.

TABLE 6.5

Means for Conditions of the Inseparable Prefix.[a]

Experimental			Control		
No-priming	*M1*	*M2*	*No-priming*	*C1*	*C2*
(betonen)	*(be)*	*(tonen)*	*(begonia)*	*(be)*	*(gonia)*
538	515	512	534	508	512
	[23]	[26]		[26]	[22]

[a] Mean naming latencies (ms) for the experimental and the control words without a prime (No-priming) or primed by either their first morpheme (M1) or second morpheme (M2), or primed by a nonmorphemic string in the control conditions (C1 and C2, respectively). Square brackets indicate the amount of facilitation in ms.

The mean naming latencies for the conditions of the inseparable prefix part are shown in Table 6.5. No difference was found in facilitation between the experimental and the control items in the M1 condition ($t < 1) = 0.49$, $MSE = 388.92$, $p > 0.05$). The difference between the experimental and the control items in the M2 condition also failed to reach significance ($t < 1) = 0.66$, $p > 0.05$).

DISCUSSION

Before discussing the pattern of data we first briefly mention some general methodological aspects of the experiment. The design of this study used experimental and control groups of words. As can be seen in Table 6.1 these groups were fairly well matched for naming time in the nonpriming condition. Only in the inflectional prefix subexperiment was a significant difference in naming time obtained. The effect of priming is calculated by subtracting *within* either the experimental or the control group of words, so the absolute size of the nonpriming condition is not very crucial. However, the amount of priming obtained could well be a function of the response time (RT) in the nonpriming condition in that words that have relatively slow naming times would show more priming. In the inflectional prefix condition, the RTs in the NO-PRIMING condition are higher in the experimental group, which means that the priming effect in this group might be overestimated. The data analysis, however, shows no significant difference. This suggests that the interpretation of the results of the inflectional prefix subexperiment as showing no morphological priming is justified.

Our results can be briefly summarized as follows. First, there were only effects of morphological structure for derivationally complex verbs with separable particles, both when priming involved the preposed particle and when priming involved the verb part of the complex verb. This indicates that our task is in principle sensitive enough to show effects of morphological structures and allows us to interpret the results of the other three subexperiments as not simply due to a lack of sensitivity. Second, the morphological priming occurred for verbs with separable particles. In the introduction we have claimed that it seemed necessary that especially those verbs should have their morphological structure reflected in the lexicon. Our finding is in line with this.

Inflectionally Complex Forms

The AAM model of Caramazza et al. (1988) predicts priming effects for the inflectionally complex verb forms used in two of the four subparts of our experiment. However, all priming effects obtained in those two parts were not larger than the priming obtained with similar strings without morphological status.

Caramazza et al. (1988) used as their materials Italian inflected verb forms (and nonwords with varying morphological structure, using Italian verb stems and affixes). They found evidence for a decomposed lexicon for these forms whereas we did not. This outcome is somewhat similar to that of Jarvella et al. (1987), whose results also suggested a decomposed lexicon for Italian inflected verb forms. However, they found no evidence for the existence of the complete full form as an entry. For Dutch, the results showed a pattern similar to that which the AAM model would have predicted. This latter study, however, still lacked controls with nonmorphological parts of words as priming strings.

Although not totally conclusive, their results show decomposition in the lexicon for Italian and not for Dutch inflected verb forms. It is possible that this is due to the different properties of the verb inflectional systems of these languages. The Italian language has a much more complicated verb inflectional system than the Dutch language. This means that the amount of storage saved by only storing stems and affixes of verbs and not storing all full forms would be much larger for Italian than for Dutch. Thus, if a difference emerges when these languages are investigated in psycholinguistic experiments, then one would expect effects indicating a decomposed lexicon for Italian verbs but not for Dutch verbs. The opposite finding would be rather counterintuitive. In other words, the AAM model might be the right one for some languages but not for all languages. This clearly points to the importance of cross-linguistic comparisons in psycholinguistic research (see also Mitchell, Cuetos, and Zagar, this volume).

Derivationally Complex Verb Forms

Our results are problematic for models that assume prefix stripping or left-to-right parsing. Both type of models predict morphological priming effects for both of the types of derivationally complex verbs we used. Our results, however, showed significant morphological priming only in the case of verbs with a preposed, separable particle. We have postponed, so far, further discussion of problems associated with a fully decomposed lexicon, that is, a lexicon where the only access units are the simple morphemes, both bound and free. As stated before, we think that for a language like Dutch (and presumably also for English, cf. Henderson, 1985) this is simply not a realistic option. First, there is the problem of noncompositionality. Many of the derivational complex forms are noncompositional, and even when they seem to be compositional they often still have idiosyncratic meaning aspects. But there is also a computational issue. A fully decomposed lexicon entails processes like affix stripping. That is, a complex word form should be disassembled in order to access the different morphemes. But in many cases something will be stripped that was not a prefix after all, in the case of so-called pseudoprefixes like *premium* and *sublime*. We have begun some computational research on the relative occurrences of prefixes and pseudoprefixes in Dutch using the CELEX lexicon containing 110,000 lemmas with frequency information based on a 44-million-word corpus. Preliminary results show that for Dutch, prefix stripping is not a very attractive option (Schreuder & Kusters, in preparation). In approximately 75% of the cases that a prefix would be stripped from a word in our corpus, it turns out to be a pseudoprefix. Therefore, from a computational point of view, prefix stripping should be avoided, making a fully decomposed lexicon unattractive for Dutch.

Morphological Priming in a Nondecomposed Lexicon?

This leaves us with a Dutch lexicon that is not decomposed. Remember that the verbs for which we did find effects of morphological structure consisted of a preposed particle and a verb. Both the particle and the verb part of these verbs occur as free morphemes in Dutch and need to have their own access representation in the lexicon by definition. They have to be represented in the access lexicon according to *any* theory. Therefore, we would suggest that our results are consistent with a full listing hypothesis (e.g., Butterworth, 1983). We still have to explain, then, why we found an effect of morphological priming for verbs with separable particles.

Our account of this finding is as follows. We assume that all free-occurring particles like prepositions and all (inflected) forms of simple verbs are connected with the entry of the corresponding complex form if it exists in the language. That is, we assume that the entry for the preposition *aan* is connected with *aanvallen*, 'to attack', *aanpassen*, 'to adapt', *aankijken* 'to look at', and so on. Similarly the entry for *vallen* is connected with *aanvallen* but also with *afvallen* 'to lose weight' and all other complex verb forms that contain the verb part *vallen*. Earlier, we stated that a particle (e.g., a preposition) of a complex verb can appear many words later in the sentence than the verb stem. When the preposition is recognized it still has to be combined with the verb part to look for the meaning of the combination that is most often noncompositional. Compare *Zij viel ondanks alle problemen uiteindelijk aan*, 'Despite all problems she finally attacked', and *Zij viel ondanks alle problemen uiteindelijk af*, 'Despite all problems she finally lost weight'.

According to our proposal, access representations of simple verbs and those of free-occurring particles like prepositions and adverbs are connected with the access representations of the complex verbs that contain their combination. When such a simple verb or a particle is accessed, activation will spread to the access representations of the complex verbs to which they are connected. When, separated in time, both are accessed, their combined influence on the access representation of the complex form should be enough to trigger it and so make available the idiosyncratic information that is unique for *this* particular combination of verb and particle.

This account entails the following critical prediction. Because there is no connection between simple verbs and complex verbs with a nonseparable prefix, we predict that the verb *vallen* will activate the complex verb *aanvallen* (preposition) but not *bevallen* which contains the same verb but now with an inseparable prefix. The reason for this is that during reading, the verb *vallen* never needs to be recombined with a prefix like *be* coming later in the sentence. This prefix is *always* attached to the verb and therefore no links between prefix, verb, and complex verb access representations are necessary. Currently, we are exploring these aspects of our account of this interesting process that we would like to call *distributed lexical access*.

CONCLUSION

In this chapter, lexical access of morphologically complex verbs was studied. Both inflectionally and derivationally complex verb forms were used. A naming task was used in which a part of a word could be given a very short headstart. When reaction times to words presented in this way are compared with the naming times of the same words presented all at once, a priming effect can be obtained. To control for graphemic priming, exactly the same or very graphemically similar subparts were presented twice: Once when they had a morphological status in a given verb and once when they did not. Only in the case of verbs with separable preposed particles did we find a significant morphological priming effect. The results are discussed with respect to existing theories of access of morphologically complex words. Also, morphological differences between languages and some computational issues are taken into account. It seems that, at least for Dutch, the full listing hypothesis is still tenable.

It is argued, furthermore, that verbs of the type that produced significant morphological priming effects pose special problems for lexical access in reading. Their subparts can be separated by a large amount of intervening verbal material, yet often their meaning cannot be computed on the basis of the meaning of the subparts alone. We offer the hypothesis that the morphological subparts of these verbs have access representations that are connected to the access representation of the complex form. These connections make it possible to retrieve the meaning information associated with the complex form when both of its subparts are presented asynchronously in time. These connections most likely produced the priming effects observed in our experiment.

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