Using Dictionaries to Study the Mental Lexicon

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The notion of a mental lexicon has its historical roots in practical reference dictionaries. The distributional analysis of dictionaries provides one means of investigating the structure of the mental lexicon. We review our earlier work with dictionaries, based on a three-way horserace model of lexical access and production, and then present the most recent results of our ongoing analysis of the *Oxford English Dictionary, Second Edition* on CD-ROM, which traces changes in productivity over time of the English suffixes *-ment* and *-ity,* both of which originate in French borrowings. Our results lead us to question the validity of automatic analogy from a set of existing words as the driving force behind morphological productivity. © 1999 Academic Press

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In this article, we discuss our use of the distributional analysis of dictionaries as a means of investigating the structure of the mental lexicon, first providing some background and then presenting the most recent results of our ongoing analysis of the *Oxford English Dictionary, Second Edition* (OED2) on CD-ROM. We concentrate on those aspects of our work that address the three-way horserace model of lexical access and production first proposed by MacWhinney (1975, 1978), our own version of which was presented in Anshen and Aronoff (1988). Many other researchers have proposed similar models of access or production, but our discussion here is meant to be general and does not address differences between particular versions of the model.

The notion of the mental lexicon has its historical roots in practical reference lexicons or dictionaries. The earliest dictionaries were lists of hard words and such lists were among the most popular early printed books. Robert Cawdrey's *A Table Alphabeticall of Hard Usual English Words* (1604) was the first monolingual dictionary of English. The notion that a dictionary should encompass the entire vocabulary of a language comes a century later.

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Dr. Johnson's dictionary (1755) is the best-known early exemplification of this notion, which was tied to codification and the idea of a language as a socially constructed object. The distinction between the internal lexicon of an individual speaker and the dictionary of the language as a socially defined object comes only at the turn of the 20th century, with the recognition that language is simultaneously social and individual (Saussure 1916).

Dictionaries, often specially constructed, have been valuable tools for the scientific study of languages. Frequency dictionaries are used routinely by psychologists for experimental purposes, while linguists use reverse-alphabetical dictionaries to study patterns of suffixation. We assume implicitly that these dictionaries are quite directly related to mental lexicons. Western dictionaries are arranged according to bold-faced entries. These entries are uninflected words, what linguists call lexemes and cognitive psychologists call lemmas (Levelt 1989). Crucially, they are not morphemes, which almost all theoretical linguists had claimed until fairly recently to be the basic building blocks of languages. This arrangement of entries by uninflected words does agree with the word-based or lexeme-based approach to morphological organization that has been adopted by morphologists over the past 20 years (Aronoff 1976, Anderson 1992, Beard 1995), an approach that has also been assumed explicitly by psycholinguists adopting either a full-listing or a dual-route model of the mental lexicon. To our knowledge, no English dictionary organizes entries around morphemes.

Psychologists assume that the counts in frequency dictionaries, which are amassed from texts, correspond quite directly to weights in native-speaker subjects' mental lexicons (or more informally to familiarity judgments). This assumption has proven by and large to be valid. Dictionaries are also routinely used to determine whether an item is a word of a given language or not. Psycholinguists use this information in constructing experiments, assuming again that the dictionary, compiled from a variety of sources, corresponds roughly to a native speaker's lexicon. Linguists do the same: ''a dictionary . . . is the closest we can come to the lexicon of a speaker's language'' (Aronoff, 1976; p. 116).

Paper dictionaries are inherently limited as research tools. They are organized along a single dimension, while the mental lexicon is clearly accessible from many dimensions and may be accessible from more than one simultaneously. The most common type of paper dictionary is organized according to the order of the letters of the alphabet, starting at the beginning of each dictionary entry. Alphabetical order has no known linguistic or universal psychological significance and standard paper dictionaries are accordingly not very convenient tools for linguistic analysis. The only type of case that we can think of offhand where word-initial alphabetical order is useful is in studying prefixes, since this order groups together words with the same prefix, but prefixes are not as common as suffixes in the languages of the world (Hall, 1992).

For morphologists, the most useful paper dictionaries are reverse-alphabetical dictionaries. These were first published as rhyming dictionaries, to be used by poets, and *Walker's Rhyming Dictionary,* which we have used for 25 years, was originally published in 1775, though it has gone through many editions since. The advantage for linguists is that by alphabetizing from the back of a word rather than the front, such dictionaries list together words ending in a given letter sequence and thus put together in a list all words in a given suffix (with the caveat that the list will also include many false hits, as with forward alphabetical lists). Since suffixation is by far the most common morphological device in English and most other languages, reverse-alphabetical dictionaries can be very useful to morphologists studying English and other languages, though reverse-alphabetical dictionaries are rare, except for the major European languages.

A basic idea of 20th-century linguistics, rooted in paper dictionaries and first made explicit by Bloomfield (1933), is that the lexicon of a language is the repository for all items that are not predictable from the grammar of the language. Conversely, any item that is entirely predictable is not listed in the lexicon. Bloomfield did not explicitly distinguish, however, between the collective lexicon of the language and the mental lexicon of individual speakers. Zimmer (1964) was the first to take advantage of this distinction, suggesting that members of productive morphological classes could be distinguished from those of unproductive classes by not being listed in the individual speaker's lexicon, but rather by being made available as needed and then discarded rather than stored.

This distinction between stored items and those created only to be discarded only makes sense when couched in terms of individual mental lexicons. It is hard to see, therefore, how one can use standard dictionaries to test the hypothesis that the members of productive morphological classes are not listed. Whether a word is listed in a dictionary is determined by written attestation and our hypothesis distinguishing listed from unlisted items permits an unlisted word to be used any number of times, so long as it is not stored in people's heads, so attestation in writing would not seem to bear on the issue of lexical listing. Nonetheless, we have been able to find two types of indirect evidence in standard dictionaries that bear on this issue.

First, not all entries are given equal status in most dictionaries. Some are *headwords,* given their own separate entries, while some are *run-ons,* placed at the end of an entry, often with no definition, because their meanings are derivable transparently from those of their heads. If the members of a morphological class that is formed productively are, by and large, not stored, we do not expect the members of this class to have idiosyncratic meanings, since any idiosyncrasies must be stored in order to be retained. We therefore expect that, when members of a very productive class are listed in a conventional dictionary (because these words have appeared in print), they are most likely to be listed as run-ons without any definition. We have claimed that

the English suffix *-ness* is productive and hence words ending in this suffix should not be listed in speakers' mental lexicons. This expectation is borne out by data from *Webster's Seventh Collegiate Dictionary.* Of the 619 words of the forms *Xiveness, Xousness,* and *Xibleness* in the dictionary, only 3 are listed as headwords, while 37 of the words in *Xivity, Xosity,* and *Xibility* are listed as headwords.[1]

Our second type of evidence comes from first and last citations. The *OED* is a historical dictionary, concerned not only with the contemporary language, but with the entire growth and history of written English. The editors of the *OED* took very seriously their goal of tracking down the first use of every word recorded in the written language and then tracing the history of the use of these words through time. We have been able to use this information to study the birth and death of morphological processes in English. Our research shows that not all morphological processes are born and die in the same way and we have used this last finding to shed light on theories of lexical access. Our earliest work in this area was done with both a reverse dictionary and a paper version of the first edition of the *OED* and dealt only with first citations. Our goal was to differentiate *Xiveness,* which we have found on other grounds to be highly productive, from *Xibleness,* which, based on experimental and frequency data, seems to be dead. Lexical listing alone does not differentiate the two: few members of each class are listed separately. However, if we look at the growth of the two patterns, they are very different. The number of new *Xiveness* words grew steadily over 400 years, while new *Xibleness* words, of which as many are attested before 1600 as *Xiveness,* never increased much in number and dwindled almost to nothing in the 19th century, indicating that the *Xibleness* pattern never grew much and is now dead.

We used the electronic tape version of *OED2* for our second set of studies on citations, which was expanded to include not only first but also last citations, which we could search for on the tape. Using last citations allowed us to investigate another prediction, first noticed by Broselow (1977), that follows from the claim that the output of productive morphological processes is not listed: if a productive morphological process dies, then it should die suddenly, with the result that we should find in the dictionary a sudden drop-off of citations for words formed according to the most productive patterns. Our findings on last citations also support a theoretical distinction between more and less productive patterns: in Anshen and Aronoff (1988), we had proposed a three-way horserace model of lexical access, distinguishing rule, rote, and analogy, with two major distinctions between rule-governed (fully productive) and analogical (less productive) formation: (1) the output of productive rules is not stored while the outputs of analogical processes are stored and (2) analogical processes operate by calculating partial similarities over

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[1] Not all dictionaries follow this practice. The *OED,* for example, does not.

a set of stored words, while productive rules do not need to have access to stored items and are hence both faster and insensitive to frequency. Our earlier dictionary studies addressed only the first question. But in studying last citations, we found two distinct types of fall-off in last citations that distinguished more productive from less productive affixes, at least in their demise. For the less productive affixes, there is no sudden fall-off in use, but rather individual words linger for centuries, suggesting that these affixes were never fully productive and the words formed with them therefore stored individually and supporting the distinction made in the model between fully productive and partially productive processes.

In our most recent work, we have turned from death to birth. Using the latest in dictionary technology, the *Oxford English Dictionary* on CD-ROM, we have been able to investigate the birth and development of a morphological rule over a period of close to 1000 years. As should be obvious by now, we have had a long and continuing interest in the English suffixes *-ity* and *-ness* (Aronoff, 1976, 1983; Aronoff & Schvaneveldt, 1978; Anshen and Aronoff, 1980, 1997). What makes these two suffixes fascinating is that, although they have competed for the same ecological niche in the language for the better part of a millenium, both have survived. The two suffixes are used to form abstract nouns meaning ''the quality of . . .'' from adjectives; *-ness* is a native Germanic suffix whose origins long predate the written history of English, while *-ity* is ultimately of Latin origin (Lat. *-i-tas*), though the earliest forms were borrowed from French. Our assumption all along has been that by comparing two affixes that are so similar and that compete in this way, we can gain a better understanding of morphological productivity and, more generally, of morphological competence, how morphologically complex words are processed in the human mind. As we have already noted, in Anshen and Aronoff (1988) we presented a three-way competition model for morphological production. In Anshen and Aronoff (1997) we showed how support for this psychological model could be gained from the analysis of the demise of certain derivational prefixes through the recorded history of English. Our current work is similarly historically based and psychologically motivated. It differs from its predecessors primarily in its method: all data in this article have been obtained from the *Oxford English Dictionary* on CD-ROM, both by the use of the search tools included with the disk and by hand refinement of the data extracted.

We take it as a starting point that forming new words in *-ity* and *-ness* are rule governed processes, as opposed to the *ad hoc* formations that yield *motel, orientate,* and *cheeseburger.* We are interested here in how rules such as this become part the language, *i.e.,* part of speakers' competence. In this search, *-ness* is of little help; it is a West Germanic form and has been in English as long as the language has had a separate existence. The suffix *-ity,* on the other hand was originally introduced into English with the flood of words of Romance origin, becoming significant about 200 years after the

TABLE 1
Statistics for the Suffix -ity

Half-centuries	Total -ity	Borrowed -ity	Derived -ity	Percentage of derived -ity
1251–1300	18	17	1	5.56
1301–1350	25	24	1	4.00
1351–1400	115	104	11	9.57
1401–1450	80	69	11	13.75
1451–1500	92	76	16	17.39
1501–1550	167	145	22	13.17
1551–1600	191	127	64	33.51
1601–1650	436	230	206	47.25
1651–1700	300	59	241	80.33
1701–1750	129	21	108	83.72
1751–1800	198	21	177	89.39
1801–1850	454	19	435	95.81
1851–1900	518	16	502	96.91
1901–1950	300	2	298	99.33
1951–2000	179	0	179	100.00

Norman Conquest. There are no attested -ity words in English prior to 1066. In what follows, we investigate how English acquired the new suffix -ity and made it its own.

The distribution of new -ity words entering English in each half-century since 1251 is presented in Table 1, along with a breakdown of the number of these new words that were borrowed from French or Latin and the number that were derived in English.

Two things are obvious from this table. The first is that the number of borrowed -ity forms slowly increases and then, starting at the second half of the 17th century, decreases. This decrease reflects a general shift away from borrowing as a way to acquire new lexical items in English, as shown in Fig. 1.[2] The second obvious observation is that there was increasing usage of derivation in -ity as a word forming tactic of English. These two tendencies taken together are shown in Fig. 2.

What we see in these tables is the growth in English of a new productive morphological process, something which has never been documented in such detail before and which is possible only because of the ease of accessing that the *OED2* on CD-ROM provides. While the formation of new -ity words in English is clearly a novel and sporadic process in the 13th and 14th centuries, driven by analogy, by the beginning of the 17th century, there is clearly a regular morphological process in English providing for the regular forma-

[2] We have shown only French borrowings in Fig. 1, as they are both the most numerous borrowings into English and the easiest to extract from the *OED*.
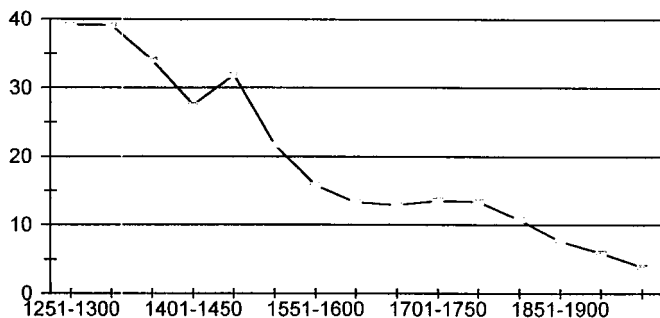
FIG. 1.   French borrowings as a percentage of all new words.

tion of new words in *-ity.* This process yields more than 100 new words in *-ity* in each half-century beginning in 1601.

It is interesting to contrast the fate of *-ity* in English with that of *-ment,* as shown in Table 2. Both are noun-forming suffixes of Romance origin. Both show a steady decrease, beginning in 1651, in the number of borrowed forms, and therefore an increase in the percentage of derived forms. The suffix *-ment,* however, does not show the continued growth in derived forms that *-ity* does. Table 3 compares the number of derived *ity* forms with those of *-ment* directly. For *-ment,* the half-century from 1601 to 1650 shows the highest absolute number of derived forms, while for *-ity,* although this half century is higher than any previous half century, 4 half-centuries after this show a greater number of derived forms. There are but 30 new derived *-ment* forms in the 20th century and 477 new *-ity* ones. This is despite the fact that, as shown in the graph, there were more new derived *-ment* forms in every half century looked at up until 1650. Clearly *-ment* is not a productive affix in modern English as shown informally by the difficulty of thinking of a new word in *-ment.*

It is possible to explain the success of *-ity* and the failure of *-ment.* One
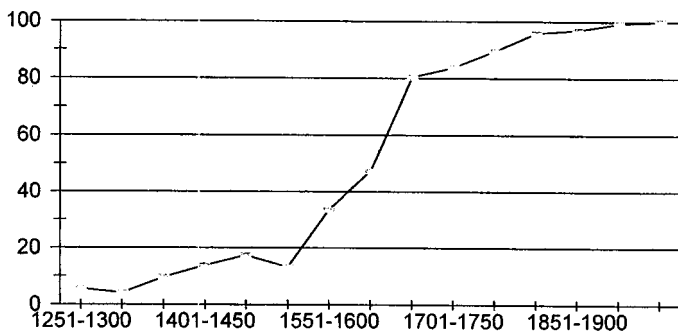

FIG. 2.   Derived *-ity* as a percentage of all *-ity* words.

TABLE 2
Statistics for the Suffix *-ment*

Half-centuries	Total *-ment*	Borrowed *-ment*	Derived *-ment*	Percentage of derived *-ment*
1251–1300	54	48	6	11.11
1301–1350	50	40	10	20.00
1351–1400	77	58	19	24.68
1401–1450	61	46	15	24.59
1451–1500	99	62	37	37.37
1501–1550	131	71	60	45.80
1551–1600	265	91	174	65.66
1601–1650	322	105	217	67.39
1651–1700	130	54	76	58.46
1701–1750	75	35	40	53.33
1751–1800	53	16	37	69.81
1801–1850	200	42	158	79.00
1851–1900	160	18	142	88.75
1901–1950	35	9	26	74.29
1951–2000	4	0	4	100.00

striking fact is the relative success of the forms in the last half of the 17th century. Derived *-ity* forms numbered 241 while derived *-ment* forms numbered but 76. While both *-ity* and *-ment* form new nouns, *-ity* attaches principally to adjectives while *-ment* attaches principally to verbs. Interestingly, as shown in Fig. 3, the fate of adjectives and verbs in English changed at

TABLE 3
Derived Forms for *-ment* and *-ity*

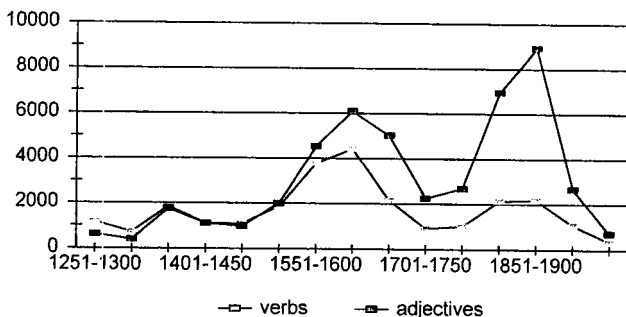| Half-centuries	Derived *-ment*	*Derived -ity*
1251–1300	6	1
1301–1350	10	1
1351–1400	19	11
1401–1450	15	11
1451–1500	37	16
1501–1550	60	22
1551–1600	174	64
1601–1650	217	206
1651–1700	76	241
1701–1750	40	108
1751–1800	37	177
1801–1850	158	435
1851–1900	142	502
1901–1950	26	298
1951–2000	4	179

FIG. 3. Number of new English verbs and adjectives.

about the same time that -*ity* worked its way into the language and -*ment* began to fade. Until 1551, there were approximately the same number of new verbs and adjectives coming into the language, with a little advantage for verbs at the beginning of our time span. During this period, -*ment* was a more productive suffix than -*ity*. We see a decrease in the number of new verbs in English compared to the number of new adjectives beginning in 1551 and accelerating sharply in the half-century beginning in 1601. Thus -*ity* had successively more targets to shoot at than did -*ment* and thus more hits.

Interestingly, as shown in Fig. 4, even while -*ment* was dying as a productive rule of English and -*ity* was establishing itself, English continued to borrow more -*ment* words than -*ity* ones. Indeed, the disparity between the two increased. Up until 1500, English borrowed about the same number of each form; however, beginning in the 16th century, there are twice as many or more borrowings in -*ment* in each half century.

Comparing -*ity* with -*ment* we see that they had similar careers, both becoming progressively more productive up until the beginning of the 17th century. Here they went their separate paths, -*ity* becoming an established rule of English morphology while -*ment* falls in productivity until today, when it is defunct. Thus it has suffered the same fate as *of-* and *at-,* albeit
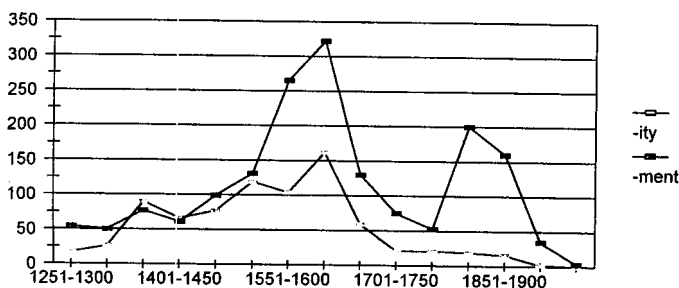

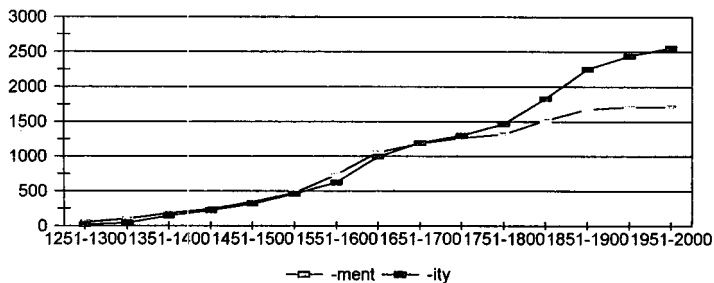**FIG. 4.** Number of borrowed -*ity* and -*ment* words.

FIG. 5. Cumulative number of *-ment* and *-ity* forms in English by half-centuries.

at a considerably slower pace. Both the 17th century, which was the downfall of derived *-ment,* and the 14th century, in which the now-obsolete but once highly productive Old English prefixes *of-* and *at-* ceased to be available to derive verbs from verbs, as we showed in Anshen and Aronoff (1997), were periods of low overall productivity in the language, the reasons for which we cannot speculate on here. The small number of overall new formations, however, seems to have been a proximate contributing cause to the loss of the word formation rules. The difference is that while the forms in *of-* and *at-* were created as needed and never entered the mental lexicon and thus vanished when the rule ceased to be productive, the forms created in *-ment* were placed in the mental lexicon, so we still have a large number of such forms in common use.

Finally, consider the data in Fig. 5, showing the cumulative number of *-ity* and *-ment* forms in English by half-centuries. While it is in the mid-17th century that *-ity* begins to be a powerful productive force in English word-building and that *-ment* begins to lose productivity, it is not until the mid 18th century that there are noticeably more *-ity* words in English than *-ment.* It would seem that the relative scarcity of new *-ment* words is a result, rather than a cause, of the loss of productivity of the rule V + *-ment* = N.

This result poses a formidable obstacle to those who would argue in favor of quantitative analogy rather than rules in English word formation, as connectionists, for example, must do. The reason is simple: if mere quantity were a sufficient basis for productivity, then *-ment* would never have diminished in productivity, since, even at the time of the end of the productivity of this suffix, there was a large number of existing words in *-ment,* certainly more than words ending in *-ity.* Furthermore, the surviving words in *-ment* that were left in the lexicon after the diminution of productivity never led to a resurgence in the productivity of this suffix. Apparently, a language can have in its lexicon a fairly large number of words from which one could potentially analogize to a productive pattern without any consequent productivity. In the case of *-ment,* we have shown that the situation is particularly dramatic: a once-productive pattern demised, leaving behind a fairly large residue, whose existence never led to a revival.

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