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Productivity

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Abstract

Morphological productivity is the property of a morphological process to give rise to new formations on a systematic basis. This article discusses the nature of this property, addressing the question whether productivity is a qualitative or a quantitative notion, how productivity can be measured and whether productivity of a process is a primitive, non-derivable property of word formation rules, or an epiphenomenon resulting from independent forces. Taking into account the way complex words are stored and processed in the mental lexicon, it is ar-

gued that the productivity of a given process emerges as a syndrome of properties, with parsability, relative frequency, semantic and phonological transparency as important factors. Finally, restrictions on productivity are discussed.

1. Introduction

Speakers of a language coin new words on the basis of other words or word-forming elements on a daily basis. For example, English speakers turn adjectives like *blue* into nouns by adding the suffix *-ness*, yielding *blueness*, or form compounds by joining existing words, as in *computer screen*. Some of these words may eventually make it into the common vocabulary of the speakers, but many newly coined words are never more widely used.

Word-formation processes are to a large extent rule-governed, but one observes that some of these processes (or affixes) are quite often used to coin new words, whereas others are less often used, or not used at all for this purpose. For example, it seems that no new noun can be formed in Modern English with the help of the suffix *-th* (as in *depth* or *length*), while the nominal suffix *-ness*, which is similar in function, is found very often in new formations (cf. *eco-friendliness*, first attested in 1989, *OED*).

In this sense, some morphological rules are called productive and other rules unproductive or less productive. Given the differences in productivity among different rules, several theoretical and empirical problems need to be

addressed. First, what makes a given rule productive or unproductive? Second, how can the productivity of a given rule be measured and which mechanisms are responsible for the variability in the productivity of morphological processes? Third, should productivity be regarded as a theoretical primitive, i.e. a non-derivable property of word formation rules, or an epiphenomenon, i.e. a property that results from other properties of the rule in question?

In the following we will first look at different definitions and measurements of productivity (section 2), then turn to the psycholinguistic mechanisms influencing the productivity of word-formation rules (section 3), and finally discuss pragmatic and structural restrictions on productivity.

2. Defining productivity: Qualitative and quantitative approaches

One important theoretical question concerning the nature of productivity is whether productivity is a quantitative or a qualitative notion. Some scholars have argued that productivity is of a qualitative nature, and that a process or affix thus either has this property or not. Others view productivity as a gradual phenomenon, which means that morphological processes are either more or less productive than others, and that completely unproductive or fully productive processes only mark the end-points of a scale.

2.1. Productivity as a qualitative notion

The term 'productivity' as broadly defined in morphology textbooks refers to the property of an affix or morphological process to give rise to new formations on a systematic basis (cf., for example, Adams (1973, p. 197), Bauer (1983, p. 18), Spencer (1991, p. 49), Plag (2003, p. 44)). Such a definition may suggest that productivity is an all-or-nothing property of morphological processes. Following Corbin (1987), Bauer (2001) advocates such an approach, dividing productivity into two distinct phenomena, one of them qualitative, the other quantitative in nature: availability and profitability. A morphological process is available if it can be used to produce new words. "Availability is a yes/no question: either a process is available or it is not." (Bauer, 2001, p. 205). Profitability, on the other hand, is a quantitative notion and refers to the extent to which a morphological process gives rise to new pertinent formations.

The most problematic point concerning availability is the notion of 'morphological process' (or often called 'word formation rule') itself. Given a set of apparently morphologically related words, it is not always clear whether one can in fact speak of a word-formation rule. In general a rule is assumed if there is a sufficient number of regular form-meaning correspondences across a larger set of words. The theoretical status of such patterns is however controversial. Proponents of analogical models of word-formation argue that traditional 'rules' or 'processes' are just a larger set of words that are related to one another by analogy (e.g. Becker 1990, or, more recently, Skousen et al. 2002). And anal-

ogy is also used to coin words on an individual, idiosyncratic basis. In a purely qualitative approach to productivity, an unproductive process could not give rise to new formations at all. However, supposedly unproductive processes sometimes do yield new formations, because speakers use existing derivatives to form new words by way of proportional analogy (cf. *greenth*). The problem with such rare coinages is where to draw the line between productive and unproductive processes. It is unclear how many such analogical formations would be needed to make a process productive (in the sense of 'available').

In view of these problems, a different line of research has abandoned the qualitative notion of productivity and has turned instead to the problem of how to determine exactly the profitability of word-formation processes. Different measures have been developed by which the productivity (here: profitability) of processes can be assessed, according to which completely unproductive and fully productive processes are conceived of as end-points on a continuum of productivity.

2.2. Productivity as a quantitative notion

Already in 1948, Bolinger explicitly put forward the idea that productivity is a probabilistic notion, defined as "the statistical readiness with which an element enters into new combinations" (p. 18). Since then, a number of productivity

measures have been proposed that try to mathematically model the notion of productivity.

A widely-used measure is the number of attested types (i.e. different words) with a given affix at a given point in time, for example by counting the number of pertinent forms in an unabridged dictionary. This measure, however, is indicative rather of past than of present productivity. Thus, there may be many existing pertinent words, but present-day speakers may not use the process any more to coin new words. For instance, the nominalizing suffix *-ment* (*entertainment, punishment, etc.*) occurs in many established words of English, most of which entered the vocabulary between the mid-sixteenth and the mid-nineteenth century (e.g. Bauer, 2001, p. 181). Today, the suffix has ceased to be productive. Another case in point is the verb-forming suffix *-en* (as in *blacken, strengthen* etc.), which is attested in numerous words, but hardly any of them was coined after 1900 (Plag, 1999, p. 98).

Aronoff (1976) proposes to calculate the ratio of actual to possible words as an index of productivity. The term 'actual word' designates existing established words, and 'possible word' refers to all words that - if formed - would be morphologically well-formed according to the pertinent word-formation rule. The higher Aronoff's index, the higher the productivity of a given rule. A major weakness of this index is that it makes wrong predictions for extremely productive and completely unproductive processes. For example, for highly productive affixes like *-ness* the number of potential words is, in principle, infinite, which yields a very low productivity index. Unproductive rules like *-th* nomi-

nalization pose the problem that the ratio of actual to possible words is very hard to calculate. If one considers all actual words with this suffix as possible words, the ratio equals 1, which, counterfactually, would indicate full productivity. Alternatively, if the number of possible words with this suffix is considered zero, the index cannot be computed at all.

A more promising way of determining the productivity of an affix is counting those derivatives that were newly coined in a given period, the so-called neologisms. Applying this measure to different periods of time, one can even show how productivity changes over time. Assessing the number of neologisms in a given period is, however, methodologically problematic since there is no established way of keeping track of all the words appearing (and disappearing) within a given period of time. Scholars therefore usually rely on unabridged historical dictionaries like the *OED*, which aim at giving thorough and complete information on all words of the language. For example, between 1900 and 1985, 284 new verbs with the suffix *-ize* are listed with their first attestations in the *OED* (Plag, 1999, chapter 5), which is an indication of the productivity of this process. Unfortunately, unabridged historical dictionaries like the *OED* are not available for the great majority of the world's languages, which seriously undermines the usefulness of this type of measure. Furthermore, the power of the dictionaries as a tool for measuring productivity should not be overestimated, because of the unavoidable lack of systematicity in the sampling procedure. For instance, the number of *-ness* neologisms listed in the *OED* for the 20th century ($N=279$, Plag, 1999, p. 98) roughly equals the number of *-ize*

neologisms, although *-ness* is generally considered much more productive than *-ize* (e.g. Plag et al. 1999, Hay & Baayen 2002). In view of the problems involved with dictionary-based measures (even if a superb dictionary like the *OED* is available), Harald Baayen and his collaborators (1993 et seq.) have developed some corpus-based productivity measures, which all rely on the availability of very large electronic text corpora.

One corpus-based measure is the number of types (type-frequency V), which only differs from the first dictionary-based measure in that it is calculated on the basis of a representative language sample.

To estimate current instead of past productivity, Baayen developed measures that rely heavily on forms that occur only once in a corpus, the so-called hapax legomena (or simply 'hapaxes'). In very large corpora hapaxes tend to be unfamiliar words to the hearer or reader. The crucial point now is that unfamiliar complex words can nevertheless be understood if there is an available word-formation rule. This rule then allows the decomposition of the newly encountered word into its constituent morphemes and the computation of the meaning of the derivative on the basis of the meaning of the constituents. Productive processes are therefore characterized by large numbers of low frequency words and small numbers of high frequency words. The many low frequency words keep the rule alive, because they force speakers to segment the derivatives and thus strengthen the existence of the affix. Unproductive morphological categories will, in contrast, be characterized by a preponderance of

words with rather high frequencies and by a small number of words with low frequencies.

Coming back to hapaxes, we can state that it is among the hapaxes (as against words that have a higher frequency) that we can expect the highest proportion of neologisms (Baayen & Renouf 1996, Plag 2003). In other words, the number of hapaxes of a given morphological category correlates with the number of neologisms of that category. Many hapaxes are indicative of many neologisms, hence of the productivity of the rule in question.

The size of the corpus is of crucial importance for this measure. If the corpus is too small, hapax legomena will tend to be well-known words of the language. With increasing corpus size, however, the proportion of neologisms among the hapax legomena increases, and it is precisely among the hapax legomena that the greatest number of neologisms appear. The number of hapaxes is therefore an important measure for estimating the productivity of a morphological process.

Based on the number of hapaxes, the probability of encountering new formations can be computed as follows. Baayen's 'productivity in the narrow sense' is calculated as the ratio of the number of hapaxes with a given affix and the number of all tokens containing that affix. This ratio represents the probability of finding a hitherto unattested word (i.e. 'new' in terms of the corpus) among all the words of that category. The following formula formalizes this (P = 'productivity in the narrow sense', n_1^{aff} = number of hapaxes with a given affix, N^{aff} = number of all tokens with that affix).

$$(1) \quad P = \frac{n_1^{\text{aff}}}{N^{\text{aff}}}$$

A large number of hapaxes leads to a high value of P , indicating high productivity. Large numbers of high frequency items lead to a high value of N^{aff} , hence to a small value of P , which indicates low productivity.

If one applies the different measures proposed above to a set of affixes, one can observe that the ranking of affixes differs according to the type of measure used. For example, the figures provided in Plag et al. (1999) or Plag (2002) indicate that some suffixes that score comparatively high for one measure, may score comparatively low for another measure.

Crucially, such apparent discrepancies are not a sign of the inadequacy or uselessness of these measures, but show that each measure highlights a special aspect of productivity. Compare, for example, the adverb-forming suffix *-wise* and the nominal suffix *-ness*:

Table 1: Productivity measures for *-wise* and *-ness*, taken from Plag et al. (1999)

	<i>V</i>	n_1^{aff}	N^{aff}	<i>P</i>	OED neologisms
<i>-wise</i>	183	128	2091	0.061	12
<i>-ness</i>	2466	943	106957	0.0088	279

-Wise has a low number of types *V* and a low number of hapaxes n_1 , which indicates that the suffix is not used very often, neither in terms of different derivatives, nor in terms of new formations. Nevertheless, among all tokens with that suffix (i.e. N^{aff}), the number of hapaxes is quite high, leading to high value of productivity in the narrow sense *P*. This is a sign of the suffix's potential to be easily used for the coinage of new forms, if need be.

The suffix *-ness*, on the contrary, scores very high in terms of type-frequency *V* and also has many OED neologisms. Its *P* value is, however, significantly lower than that of *-wise*, because many *-ness* words are also quite frequently used (e.g. *happiness*), leading to a high number of tokens N^{aff} and thus an overall decrease of *P*.

The quantitative measures are subject to another important factor, the type of genre the data are taken from. Statements about productivity are usually not qualified with regard to this factor, although it is well-known that certain affixes are more commonly found in certain types of text than in others. In a large-scale corpus-based study of the effect of written versus oral genres, Plag

et al. (1999), for example, show that, in general, derivational affixes are less productive in spoken than in written language. Schneider (2003) demonstrates that the productivity of diminutives varies according to kinds of speech act.

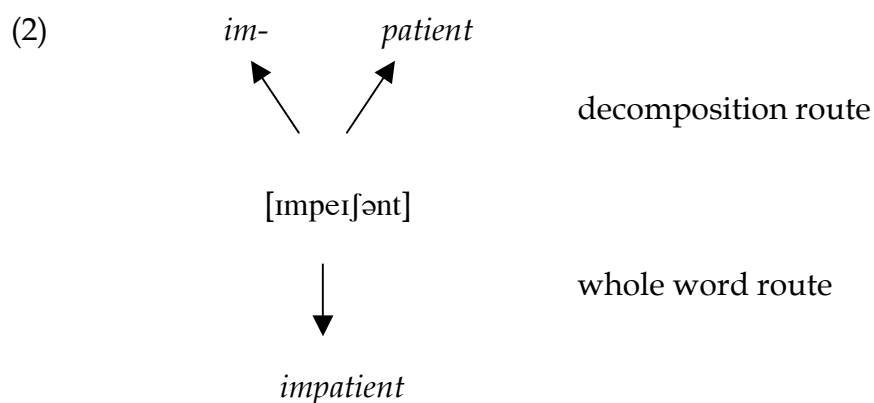
To summarize, a number of different measures have been developed to assess the productivity of word-formation rules. Each measure brings to the fore different aspects of morphological productivity and involves special methodological problems of data sampling and analysis.

3. Psycholinguistic aspects: Productivity and the mental lexicon

Having established the productivity of a morphological process, a number of new questions arise. First, how do speakers know whether a process can be used to coin new words or not? In other words, what do productive processes have in common that unproductive processes do not have? And which properties of affixes give rise to different degrees of productivity? Answers to these questions are provided by recent psycholinguistic research into the nature of complex words. The central point of this research with regard to the nature of productivity is that the productivity of an affix is a reflection of the storage and processing of the complex words containing this affix.

In current models of morphological processing, morphologically complex words can be stored and accessed in two ways: by direct access to the whole word representation (the so-called '**whole word route**') and by access to

the individual morphemes, involving the decomposition of the complex word (the so-called '**decomposition route**') (see McQueen and Cutler 1998 for an overview). According to some models, the two routes work parallelly in competition, in other models only one route is applied at a time, depending on the kind of word. The two routes are schematically shown in (2):



Whether a given word prefers one over the other route crucially depends on frequency. More specifically, the degree of decomposability of a given word depends on the relative frequency of the derived word and its base (Hay 2001, 2003). Relative frequency is defined as the quotient of the frequency of the derived word to the frequency of its base:

$$(3) \quad f_{\text{relative}} = \frac{f_{\text{derivative}}}{f_{\text{base}}}$$

Usually, the base is more frequent than the derived word, so that the relative frequency is smaller than unity. For example, *detectable* has a frequency of 281 in the BNC, while its base *detect* has a frequency of 3083, giving a relative frequency of 0.0911. Similarly *loadable* has a frequency of 36 as against a frequency of 5797 for its base *load* ($f_{\text{relative}} = 0.0062$, figures taken from Plag 2002: 308). Only very few *-able* derivatives have a base that is more frequent than the derivative, for example *deplorable* ($f_{\text{relative}} = 1.088$) or *comfortable* ($f_{\text{relative}} = 1.046$). Such a profile of relative frequencies is characteristic of productive morphological processes, due to psycholinguistic reasons. In those cases where the base is much more frequent than the derivative, the base has a very strong representation, or high 'resting activation', in the mental lexicon, such that the representation of the base is much stronger than that of the derived word. This leads to a decomposition bias, since due to its high resting activation, the base will be accessed each time the derivative enters the system. If, to the contrary, the derived word is much more frequent than the base, there is a whole word bias in parsing, because the resting activation of the base is lower than the resting activation of the derivative.

If in a morphological category there is a large preponderance of derivatives with a decomposition bias, the pertinent affix will have a strong represen-

tation and will therefore be readily available to the speaker to be used in new combinations. If, on the other hand, there is large proportion of derivatives with a whole-word bias, the affix will not be readily available for the creation of new forms.

This reasoning finds support in empirical investigations by Hay and Baayen (2002, in press). These studies show that relative frequency patterns with other properties of morphological categories: low relative frequency correlates with high productivity and high semantic and phonological transparency. As discussed in section 2, productive morphological processes are characterized by a high number of low frequency words (i.e. many hapaxes, if we speak in terms of corpora). Thus productive processes have a preponderance of words with low relative frequencies, whereas less productive morphological categories are characterized by a preponderance of words with higher relative frequencies. Hay & Baayen (2002) investigate the segmentability of 80 English affixes and come to the conclusion that the more morphologically decomposable forms with a given affix are in the lexicon, the more productive that affix will be. Increased rates of parsing obviously lead to increased productivity.

A high proportion of decomposable words has another important effect: semantic and phonological transparency. The correlation between transparency and productivity has been established in many earlier publications (e.g. Aronoff & Schvaneveldt 1978, Anshen & Aronoff 1981, Cutler 1981). The basic idea is that productive processes tend to have many semantically and phonologically transparent forms, i.e. forms whose semantics can be inferred on the basis of the

meaning of the constituent morphemes, and whose sound structure is characterized by a low degree of phonological integration of affix and stem. Productive categories are semantically transparent, because their derivatives favor the decomposed route, and decomposed storage strengthens the individual semantic representations of the constituent morphemes. This leaves little room for semantic drift and opacity, which frequently arise under whole word access and storage. The relationship between phonological transparency and productivity is further substantiated in Hay & Baayen (in press), who investigate the phonotactics at the morpheme boundaries of the 80 affixes from their (2002) study. According to Saffran et al. (1996a, 1996b), or McQueen (1998), it can be assumed that speakers rely on phonotactics for the (pre-)processing of morphologically complex words and tend to posit morphological boundaries inside phoneme transitions which rarely occur inside mono-morphemic words. For example, the phoneme combination /df/ (as in *dread-ful*) is extremely rare inside mono-morphemic English words and its occurrence in any word will therefore strongly facilitate decomposition in speech perception. In contrast, combinations that are highly frequent inside morphemes, for example, /tɪ/ (as in *tip* or *instruct-ive*), will not facilitate decomposition. Since it can be assumed that decomposition in speech perception leads to decomposed storage, decomposed forms in the lexicon should lead to productivity. Hence, we expect there to be a relationship between the junctural phonotactics of an affix and the productivity of that affix. Those affixes should be more productive which create a phoneme transition at their morpheme boundary that facilitates segmentation. Hay &

Baayen indeed find a significant correlation between the kind of junctural phonotactics of an affix and that affix's productivity. The more illegal the phonemic transitions created by an affix are, the more productive that affix tends to be. Thus, the phonological make-up of an affix (and thus the kind of juncture it creates) contributes probabilistically to the likelihood of decomposition and therefore to the degree of productivity.

In conclusion, it can be stated that the productivity of a morphological process can be explained in psycholinguistic terms as a syndrome of properties, with parsability, relative frequency, semantic and phonological transparency as important factors. The productivity of an affix results, among other things, from quite complex processing factors, among which semantic and phonological transparency are also structurally determined. The semantic and phonological structure of affixes and their derivatives co-determine processing and storage of these forms in the way outlined above. The significant role of structural factors in influencing - and constraining - productivity is the subject of the next section.

4. Productivity restrictions

For a word to be coined it must somehow be useful for the speaker who creates it. No matter which function a particular derivative serves in a particular situation (labeling, syntactic recategorization, or expression of an attitude, see Plag 2003:59-60), intended usefulness crucially constrains the formation of new complex words. However, not all potentially useful words are actually created and used, which suggests that other restrictions must be at work as well. There is thus a distinction to be made between the general possibility of a new word to be formed and the opportunity to use the new word in actual speech. The former is constrained by structural factors, the latter by pragmatic factors.

4.1. Pragmatic factors

The rise and fall of affixes like *mini-* or *-nik* are prime examples of the fact that extra-linguistic developments in society, often referred to as ‘fashion’, make certain elements desirable to use and therefore productive.

A pragmatic requirement which originates in what was called ‘usefulness’ above is the nameability requirement: concepts encoded by derivational categories are rather simple and general and typically may not be highly specific or complex. A classic example of such an improbable morphological category is given by Rose (1973, p. 516): “grasp NOUN in the left hand and shake vigorously while standing on the right foot in a 2.5 gallon galvanized pail of

corn-meal-mush" is unlikely to occur in any language as the particular meaning of a denominal verbalizing affix.

4.2. Structural factors

Structural factors influencing productivity concern the traditional levels of linguistic analysis, i.e. phonology, morphology, syntax and semantics. The pertinent restrictions can be classified either as general principles affecting all processes or as process-specific restrictions.

Rule-specific restrictions demand the presence of certain properties in the base or in the derived word. Phonological constraints, to begin with, can make reference to segmental or prosodic structure, sometimes in rather intricate ways. For example, the verb-forming English suffix *-ify* only attaches to monosyllables, to words stressed on the last syllable, and to words stressed on the penultimate syllable and ending in /I/.

An example of a morphological constraint can be seen with rival nominalizing suffixes in English. Every verb ending in the suffix *-ize* can be turned into a noun only by adding *-ation*. Other deverbal nominal suffixes, such as *-ment*, *-al*, *-age* etc., are ruled out by this morphological restriction imposed on *-ize* derivatives (cf., for example, *colonization* vs. **colonizement*, **colonizal* or **colonizage*). This is a case of a base-driven restriction, since it is the base (the *-ize* verb) that demands a certain affix (*-ation*) to be attached and rules out the at-

tachment of other suffixes with the same function. Both base-driven and affix-driven restrictions seem to be necessary to account for the combinability of affixes and stems.

Semantic restrictions may also operate on bases and on derivatives. For example, derivatives in *-ee* (*employee*) must denote sentient entities, to the effect that *amputee* cannot refer to an amputated limb (see, for example, Barker 1998 for detailed discussion).

One of the most commonly mentioned type of restriction is the one referring to syntactic properties. The adjectival suffix *-able* normally attaches to verbs (as in *readable*), but not, for example, to adjectives. Another example is the nominal suffix *-ness*, which standardly attaches to adjectives (as in *fondness*), but not to verbs. Recently, the pervasiveness of such syntactic restrictions has been questioned, however (e.g. Plag in press).

Turning from rule-specific to more general restrictions, the notion of blocking features prominently (see Plag (1999, chapter 3) and Bauer (2001, pp. 126-143) for a discussion of other general restrictions that have been proposed in the literature). Token-blocking refers to the impossibility of forming a potential regular form due to an already existing synonymous word. For example, **arrivement* is blocked by *arrival*, or **stealer* by *thief*. In contrast, type-blocking refers to the impossibility to apply one rule if there is another pertinent rule (for example *-ness* and *-ity* suffixation).

One important aspect of token-blocking is that, contrary to earlier assumptions, not only idiosyncratic or simplex words (like *thief*) can block pro-

ductive formations (such as **stealer*), but that stored words in general can do so. In order to be able to block a synonymous formation, the blocking word must be sufficiently frequent. The higher the frequency of a given word, the more likely it is that the word will block a potential rival formation. Idiosyncratic words as well as regular complex words may block other forms if and only if the blocking word is stored.

Type-blocking has been said to occur when a certain affix blocks the application of another affix (e.g. Aronoff 1976). The crucial idea underlying the notion of type-blocking is that synonymous rival affixes (such as *-ness*, *-ity*, and *-cy*) each apply in a more or less restricted domain. The most unrestricted affix is the so-called general case (in our example *-ness*), while affixes with a more restricted domain are the so-called special cases (*-ity* or *-cy*). Type-blocking would occur when the more special affix precludes the application of the more general affix, which is thus an instance of Panini's law or the elsewhere principle. However, type-blocking cannot accurately account for the patterning of the data. For example, Aronoff (1976, p. 53) claims that derivatives with nominal *-ness* are ill-formed in all those cases where the base adjective ends in *-ate*, *-ent* or *-ant*, hence the contrast between supposedly well-formed *decency* and supposedly ill-formed **decentness*. This account is, however, problematic. Riddle (1985) has shown that *-ness* and its putative rivals *-ity* or *-cy* are not really synonymous, so that blocking could - if at all - only occur in those cases where the meaning differences would be neutralized. In general, *-ness* formations tend to denote an embodied attribute, property or trait, whereas *-ity* formations refer to

an abstract or concrete entity. Hence *-ity* and *-ness* lack the prerequisite for type-blocking, synonymy. Another problem is the status of forms like *decentness*. This form is listed, for example, in *Webster's Third* and *Roget's Thesaurus*, and an internet search provided 322 occurrences (www.google.com, 2 January, 2004), which indicates that *decentness* is not at all ill-formed. Furthermore, the general case *-ness* is not systematically curtailed by *-ity* or *-cy*, as shown by the many attested doublets (e.g. *destructiveness* - *destructivity*, *discoursiveness* - *discursivity*, *exclusiveness* - *exclusivity*, all from the OED). The final problem with putative cases of type-blocking is that it is often impossible to distinguish them from token-blocking. Thus, putative avoidance of *decentness* could be a case of token-blocking, since the word *decency* is part of the lexicon of many speakers, and hence capable of token-blocking.

In sum, type-blocking as a general factor constraining productivity is to be rejected. Token-blocking, however, is a relevant principled mechanism which restricts the productivity of affixes by preventing the formation of complex rival synonymous forms.

5. Conclusion

The productivity of a word-formation process can be defined as its general potential to be used to create new words and as the degree to which this potential is exploited by the speakers. Productivity can be assessed by various measures, both corpus-based and dictionary-based. Productivity emerges from the mental lexicon as the result of parsability, relative frequency, semantic and phonological transparency. Apart from constraints on processing and usage, structural constraints also play an important role in restricting productivity. Possible words of a given morphological category must conform to very specific phonological, morphological, semantic and syntactic requirements, which impose limits on productivity. Finally, in addition to rule-specific restrictions, the general mechanism of token-blocking prevents complex words from being formed if a synonymous word is already available in the speaker's mental lexicon.

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