Productivity and Generalization

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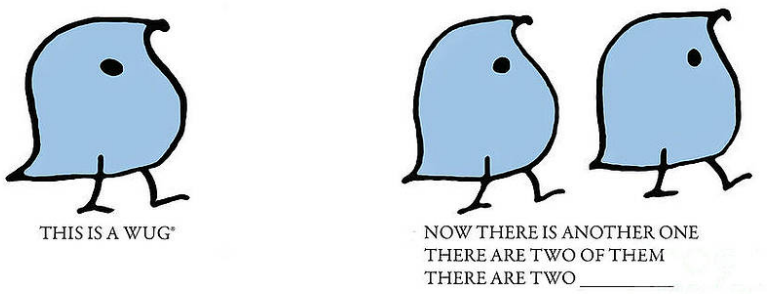
Introduction

In 1958, Jean Berko Gleason reported what would become perhaps the most important experiment in the history of PSYCHOLINGUISTICS: the Wug Test[1]. In this experiment, small English-speaking children were asked to

Psycholinguistics is the study of how language is learned, processed, and produced by the brain.

[1] Jean Berko. The child's learning of English morphology. *Word*, 14(2-3):150–177, 1958

Figure 1: Image from the original Wug Test



generalize a morphological construction to a NONCE WORD[2] Berko Gleason found that even very small children were able apply some English morphology (complete with rules of allomorphy). For example, when asked to complete a frame in which the plural of *wug* was required, children said *wugs* (pronounced /wʌgz/, with a ⟨z⟩ sound at the end).

[2] A made-up but possible word.

Pluralization with *-s* is PRODUCTIVE in English but pluralization with *-en* as in *oxen* is not. To be productive means that a construction can be applied to new inputs and, thus, yield new outputs. PRODUCTIVITY is the extent to which a morphological construction can apply to new words. Productivity is often correlated with compositionality. Morphological constructions that are more compositional are also more easily generalized to new words. That is why we are talking about it now.

Productivity

Productivity is actually multidimensional, but it might be helpful to start of visualizing it as a continuum, with default morphology on one end (mostly productive), fossilized morphology on the other (mostly not productive) and restricted morphology in the middle (productive under certain conditions). There are different suffixes for forming plurals in English. Of these, one of the least productive is *-en*, which only occurs in *oxen*, *children*, and *brethren*

fossilized	⟵	restricted	⟶	default
plural *-en*		plural *-ī*		plural *-s*

Figure 2: A continuum of productivity with English plurals. *-en* only applies to a couple of words. *-ī* applies only to Latin loanwords ending in *-us*. *-s* applies freely to all words where a more specific construction is not applicable.

Historical Stratum

Some morphological constructions only apply to words with a particular historical origin. For example, there is a negative prefix for English adjectives that is spelled *im-*, *-in*, *-ir* or *-il* depending on what follows it (a case of allomorphy). It occurs in words like the following:

(1) a. im-possible
b. in-tolerable
c. ir-regular
d. il-legal

These are all words that entered English from Latin via Norman French. There is another negative prefix as well:

(2) a. un-selfish
b. un-dutiful
c. un-answerable
d. un-knowable
e. un-knowledgeable

(3) a. un-complimentary
b. un-natural
c. un-substantial

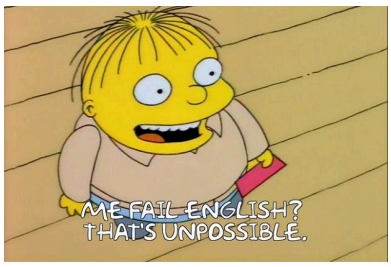


Figure 3: Ralph, a character from the once-popular animated television series, *the Simpsons*, famously defied morphological constraints.

The prefix applies to almost all adjectives from Germanic (from Old English) that you could negate, as exemplified in (2) as well as a number of words that entered English from French (3). Interestingly, the Germanic words cannot take the Latinate prefix (**in-knowable* is not okay) and the less-assimilated Latinate words (as exemplified in (1) cannot take the *un-* prefix. That is to say, **unpossible* is unpossible.

Upshot: While *un-* is a default, it apply to a historically-defined class of words. Something similar can be said of *-ness* (Germanic) and *-ity* (Latinate).

Semantic Class

Some morphological constructions only apply to words with particular SEMANTIC properties (a particular class of meanings). For example, the plural suffix 们 *-mén* in Chinese can only be attached to human nouns and pronouns:

(4) Acceptable

a. 我 -们
wǒ -mén
1SG -PL
'we'

b. 同志 -们
tóngzhì -mén
comrade -PL
'comrades'

(5) Unacceptable

a. 书 -们
shū -mén
book -PL
'books' (intended)

Morphological Constraints

Some morphological constructions only apply to inputs that have been produced in a particular way (morphologically speaking). In Russian, the FEMININE suffix *-ja* only affixes to bases that are produced by adding the suffix *-um* to a root (etc.). The feminine for all other nouns use a different suffix (*-ka*, *-ša*, *-inja*, or *-isa* [3]:

[3] Natalia Yulievna Shvedova et al. *Russkaya grammatika [Russian grammar]*. Moscow: Institute of the Russian Language, Russian Academy of Sciences, Moscow, 1980

Table 1: Words with the Russian feminine suffix *-ja*

Verb		Noun (MASC)		Noun (FEM)
goror-it^{j}	talk	govor-un	talker	govor-un^{j}-ja
beg-at^{j}	run	beg-un	runner	beg-un^{j}-ja
pljas-at^{j}	dance	pljas-un	dancer	pljas-un^{j}-ja
lg-at^{j}	lie	lg-un	liar	lg-un'-ja

Phonological Constraints

Some morphological constructions are sensitive to the sound structure (or phonology) of words to which they might apply. For example, the English suffix *-er* that makes ordinary adjectives into comparative adjectives can freely apply to words with one SYLLABLE and to many words with two syllables (following a rule we cannot yet describe) but typically cannot apply to words with more than two syllables.

A syllable, for our current purposes, is a vowel preceded by zero or more consonants and following by zero or more vowels. It is defined in terms of sounds, not letters. Words are divided into syllables in such a way as to maximize the number of syllables that start with a consonant, minimize the number of syllables that end in a consonant, and minimize the number of consonant sequences within a syllable.

(6) Acceptable

a. smarter
b. faster
c. cleverer

d. speedier
e. brainier

(7) Unacceptable
a. confuseder
b. crowdeder
c. arroganter
d. differenter
e. intelligenter
f. expeditiouser
g. adventurouser

Productivity and Psychological Reality

(8) Some assumptions that are sometimes made about grammar (including morphology)
a. Language and grammar are psychological phenomena
b. If a grammatical pattern is productive, it must be psychologically real
c. If a pattern in not productive, it must not be psychologically real (it is just fossilized historical leftovers)
d. Therefore, patterns that are not productive are not part of the language

This is problematic, though, in that it is not clear that language is just a psychological phenomenon. Certainly, natural language processing is concerned with language but is expressly not concerned with psycholinguistics. The same may be said of SOCIOLINGUISTICS and sociology of language. Furthermore, as we have seen, productivity is a continuous space—there is no solid boundary between productive patterns and fossilized or accidental ones.

In the approaches to language associated with (8), grammar is a discrete, self-contained system that defines a set of words or sentences that are in the language and (its complement) a set that are not. This view points, associated with thinkers like Noam Chomsky and Morris Halle, is still very important in theoretical linguistics and was once important in computational linguistics and NLP. However, with the empirical turn in language technologies, starting the in the 1990s and continuing up to the present, computational linguists have become much more inclined to view language as a continuous and gradient system rather than discrete one. Under such an approach, local regularities and gradient productivity cease to be anomalies. Indeed, perfect, unconstrained productivity becomes the anomaly (matching empirical observations from years of work).

References

Jean Berko. The child's learning of English morphology. *Word*, 14(2-3): 150–177, 1958.

Natalia Yulievna Shvedova et al. *Russkaya grammatika [Russian grammar]*. Moscow: Institute of the Russian Language, Russian Academy of Sciences, Moscow, 1980.