

The threshold of productivity and the “irregularization” of verbs in Early Modern English

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1. The tolerance principle, its range and limits.

Yang 2016: 10, 51 proposes a threshold for the productivity of linguistic rules of all kinds in native language acquisition (NLA) as follows. Let N be the number of lexemes which meet the structural description of the rule and e the number of exceptions (i.e., the number of lexemes which meet the structural description but are not subject to the rule). There is then a threshold

$$\theta_N = \frac{N}{\ln N}$$

such that e must be less than or equal to θ_N for the rule to be productive. If that threshold is not exceeded, so that the rule is productive, the native learner will extend the range of the rule’s application, removing exceptions one by one. If the threshold of productivity is exceeded by the number of exceptions, no change is expected; if change does occur, it proceeds by some other mechanism.

This “tolerance principle” (TP), specifying the maximum number of exceptions which a rule can tolerate in order to be productive, is compatible with a wide range of phenomena observed in NLA, including the formation of the past tense in English (Yang 2016: 24–9, 61–8), various details of verb inflection in German and Spanish (*ibid.* pp. 29–33, 61), and the scope of syntactic constructions (*ibid.* pp. 190–212). In this paper we focus on the productivity of lexical classes, i.e. arbitrary inflectional classes of major words which compete for membership, in NLA and otherwise.

Note that the TP is *not* a hypothesis about the origins of *all* linguistic innovations. At least one process of change, lexical analogy, is not subject to it. Interestingly, there is some evidence that lexical analogy is a process of innovation initiated by adults. An especially clear example relevant to the present study emerged from the celebrated “wug” study (Berko 1958). Berko presented both children and adults with nonce verbs that strongly resembled existing English irregulars, e.g. “gling”, potentially of the type *ring*,

rang or *sling*, *slung*, and “spow”, potentially of the type *grow*, *grew*. The past tenses for these verbs produced by children were almost exclusively regular, but a significant number of adults suggested *glang* or *glung*. The dichotomy between changes in the scope of rules in NLA, governed by the TP, and lexical analogy (and related processes) will turn out to be important in this investigation.

2. English verbs in *-ing*.

An especially clear illustration of the TP is furnished by the past tense of (standard) English verbs ending in /-ɪŋ/. They fall into four groups:

bring, past *brought* /bɹɔt/, unique in this subset of verbs;

ring, *sing*, *spring*, with pasts in /-æŋ/ (*rang*, *sang*, *sprang*);

cling, *fling*, *sling*, *sting*, *string*, *swing*, *wring*, with pasts in /-ʌŋ/ (*clung*, etc.);

a handful of regular verbs, all uncommon or rare; the ones that occur in the senior author’s speech are *ding*, *king* (in checkers), *ping*, *wing*, pasts *dinged* /dɪŋd/, etc., and at least some speakers also use *ring* ‘put a ring around’, past *ringed*.

The largest group, by a substantial margin, is those with pasts in /-ʌŋ/, and a “commonsense” approach to morphological change would suggest that that group should gradually acquire new members. In fact that was long the usual view: “A form which is statistically predominant is also likely to be productive for new combinations” (Nida 1949: 45). However, new past tenses in /-ʌŋ/ are conspicuous by their absence, and Yang’s hypothesis offers a reason why the situation is stable. In the senior author’s speech N is 15, and the natural logarithm of 15 is 2.70805. The quotient of those numbers is 5.539, and the TP states that no rule of past tense formation for this group of verbs should become productive if the number of exceptions to it exceeds five. In fact, no matter which rule we choose, the number of exceptions is substantially greater than five; thus it is not surprising that there is no change in progress. That remains true even for speakers whose only regular verb in this group is *wing* (the least rare of the regulars). For them N is 12, and its natural logarithm is 2.48491; the quotient is 4.829, and there are still five exceptions (*bring*, *ring*, *sing*, *spring*, *wing*) to the rule yielding past tenses in /-ʌŋ/. It’s a near thing, though. What if a speaker used no regular verbs in /-ɪŋ/? For such a speaker N is 11, its natural logarithm is 2.39790, and the quotient is 4.587, but

there are only four exceptions to the rule yielding past tenses in /-ʌŋ/ (*bring, ring, sing, spring*); thus the rule ought to be productive if there are no regular verbs in /-ɪŋ/ at all. In short, the “-ung rule” is a borderline case which might provide an opportunity to test the TP.

In fact an innovative past in /-ʌŋ/ exists in colloquial English, exemplified in the phrase *they sprung him out of prison* (Margaret Laing, p.c. 27 August 2018). The phrase seems to be U.S. slang, not much more than a century old (see the *Oxford English Dictionary (OED)* s.v. *spring*, v.¹ II.26). We cannot demonstrate that that finite past arose in the speech of a learner who used no verbs in /-ɪŋ/ with regular past tenses, but the distribution of facts makes it likely.

Other innovative past tenses that have not caught on can also be explained by the TP. Yang notes that “the productivity of a rule may change during the course of language acquisition” (p. 54), depending on the vocabulary that the native learner has learned at any given point. To judge from the 6-million-word corpus of child-directed English in the CHILDES database (MacWhinney 2000), the commonest verbs in this class, in descending order, are *bring* (past *brought*), *sing* (*sang*), and *ring* (*rang*), and it is reasonable to suppose that children learn those verbs first more often than not. The seven verbs with pasts in /-ʌŋ/ and *spring* (*sprang*) are subsequently learned in an order that must vary from child to child. Here are the productivity thresholds for lexical classes of sizes 3 through 16:

N	θ_N	N	θ_N	N	θ_N
3	2	8	3	13	5
4	2	9	4	14	5
5	3	10	4	15	5
6	3	11	4	16	5
7	3	12	4		

It can be seen that if the 4th and 5th verbs in *-ing* acquired both have pasts in *-ung*, the *-ung* rule will become productive when the 5th verb is learned. It will remain productive unless *spring* (*sprang*) is the 6th, 7th, or 8th relevant verb acquired. If *spring* is the 9th, 10th, or 11th item acquired, the *-ung* rule will continue to be productive; if *spring* was acquired earlier, the *-ung* rule will again become productive when the 9th verb is learned,

unless and until at least one regular verb in *-ing* is acquired. Thus the TP offers an easy explanation for the fact that innovative past tenses like *brung* and *sung* are occasionally produced even in the acquisition of standard English.¹ In fact, since θ_N is 2 when N is 3, the hypothesis that *bring*, *sing*, and *ring* are the first three verbs in *-ing* acquired offers an explanation for the occasional appearance of *brang* in the acquisition of standard English as well.

This line of reasoning is supported by actual evidence from NLA. Children learning English virtually always produce regular past tenses of irregular verbs (see e.g. Pinker 1999: 189–210) but seldom produce innovative irregular past tenses (Xu and Pinker 1995)—except for the *-ung* rule.² In the entire collection of North American child English transcribed in the CHILDES database, the past tense of *bring* is correct *brought* 95 times, regularized *bringed* 6 times, and irregularized *brang* or *brung* 9 times. In line with the thought experiment of the preceding paragraph, the irregular but incorrect pasts would not be possible for a speaker with a vocabulary large enough to include most of the verbs in *-ing*, but they are predicted to be spontaneously available to children who have a much smaller vocabulary. In short, we expect *brang* or *brung* to be produced at an early stage of NLA when a learner has not learned enough vocabulary to destroy the transient productivity of the rule.

Of course demonstrating in detail that this is the process leading to the production of innovative past tenses for these verbs will involve further and more intensive research on NLA. However, there is another dataset against which the TP can be tested, namely observed historical changes in a language. Since the history of English over the past six or seven centuries is especially well documented and intensively studied, we believe that it is worthwhile to attempt such a test using English historical data. That is what this paper will present.

Before we proceed, it seems advisable to clarify a methodological point. We have been asked repeatedly how the classes of verbs that we discuss should be identified; for instance, how do we know to look at English verbs ending in *-ing*? Since the TP is a

¹ However, the fact that the past tenses of *sing*, *ring*, *spring* are *sung*, *rung*, *sprung* in some dialects of English comparatively remote from the standard can be explained in more than one way; see fn. 7 below.

² See Yang 2016, ch. 2, for a crosslinguistic review of these and similar findings.

hypothesis about how native learners behave during NLA, experimental work will be required to establish what specific classes native learners of a given language posit (though even casual familiarity with NLA suggests that different learners might make different choices, and that every imaginable choice will be made at least occasionally). However, in this paper we pursue a different strategy, which can be characterized as an “interim” strategy in the absence of adequate experimental work: we start from innovations that are actually observed in NLA and changes that have in fact occurred in the history of English, and we attempt to retrofit the analysis so as to explain those developments in accordance with the TP. This approach is complementary to simple computational models of inductive learning, such as those constructed by Yip and Sussman 1997 and Albright and Hayes 2003, which operate on the phonological representations of words to produce rules such as the *-ung* rule. In either case some further hypothesis, such as the TP, is needed to assess the productivity of rules.

If we could explain everything that we observe by our strategy, the TP would be a vacuous hypothesis. However, it will be seen that there are observed developments which the TP cannot explain; most importantly, they are precisely the developments which can be explained by lexical analogy and similar processes.

3. The 16th and 17th centuries.

Over the course of the 16th and 17th centuries written English becomes increasingly uniform, but there is still a good deal of variation. In the context of that variation several noteworthy innovations in past tense formation occurred. *Stringed* was replaced by *strung*, suggesting that the *-ung* rule was productive for some speakers for at least part of that period; more surprisingly, *digged* was replaced by *dug* and *sticked* was replaced by *stuck*, suggesting that the rule was actually broader, taking as input verbs with /i/ in the root followed by any single velar consonant. We need to determine whether such a rule could have been productive according to the TP, or whether some other type of change must have occurred.

The two principal resources for investigating the development of English during this period are the *OED* and the *Penn-Helsinki Parsed Corpus of Early Modern English* (*PPCEME*; Kroch et al. 2004). The *OED* records every form attested and attempts to

give the earliest instance of each attested form, usually with (at least approximate) success. The *PPCEME*, though it includes more than 1.7 million words of running text, is not large enough to offer examples of every lexeme, let alone every form; on the other hand, it gives a fair indication of which lexemes occur most frequently, and for common lexemes it provides good information about the relative frequency of competing forms.

We also consulted the *Parsed Corpus of Early English Correspondence (PCEEC*; Nevalainen et al. 2006), but it contained too few relevant forms to contribute significantly to the relevant statistics; for instance, though *sing* is one of the commonest relevant verbs in the *PPCEME*, its finite past is unattested in the *PCEEC*, which also contains only two examples of its past participle *sung*. Forms from the *PCEEC* will be cited in the footnotes where relevant.

4. New past tense forms in Early Modern English.

The currently ascertainable facts regarding the new past tense forms noted in the last section are the following.

The *OED* records a single instance of the verb *string* from late Middle English (ME), *with bowes gode wel y-strenged* ‘with good bows well strung’, from the *Laud Troy Book*, ca. 1425; the verb *to string* (a bow or a musical instrument) next appears in the 16th century, the earliest *OED* quotations being from 1530 and 1545.³ Since the verb is clearly derived from the noun *string* (which was inherited from Old English (OE), first attested in the 8th- or 9th-c. poem *Andreas*), one would expect it to inflect according to the default pattern, with a past and past participle *stringed*. In fact *stringed* and *strung* are both quoted from the 16th c. onward, though *stringed* is gradually eliminated, falling out of use in the 18th c. In the 16th c. *stringed* is first quoted from 1530, and again from 1548 (past ptc. in both instances); *strung* (likewise past ptc.) is first quoted from Spenser (*Virgil’s Gnat*, 1591), and from Donne (1612), Chapman (1613), Shakespeare (before 1616), and obscure authors of the 1590’s and 1600’s. The past and past participle of this

³ There are also a couple of quotations each in the more obscure meanings ‘to furnish (a garment) with ties’ (first in 1548) and ‘to remove the notochord from (a lamprey)’ (1508). It is not clear whether those meanings are relevant; in any case they are rare, and the *OED* quotes no past tense for either. The now common meanings ‘to put (things) serially on a string’ and ‘to arrange in a line’ both appear first in the 17th c.

verb are not attested in the *PPCEME*. Though the attestation is too sparse for absolute certainty, it appears that *stringed* was already in place early in the 16th c. and was replaced by *strung* in literary English sometime in the second half of the century.

For *dig* the record is a bit fuller and the situation slightly clearer. The verb was borrowed from French around 1300, and a default past tense *diggede* and past participle *digged* are well attested in late ME. Regular forms continue to occur throughout the 16th and 17th centuries; the *PPCEME* has examples from Tyndale's bible (1520's and '30's, adopted without change in the King James translation of 1611), from the works of Sir Francis Bacon, William Clowes, and Richard Hooker (all late 16th c.), from the letters of Lady Katherine Paston, John Taylor, and Henry Oxinden (all latest 16th and early 17th c.), and from statute books throughout the period. Early examples of *dug* happen not to occur in the corpus, but the *OED* (under *dig*, section II.4) gives an example of past ptc. *dug* from 1580, and another occurs in the *PPCEME* sample from Pepys' diary (1660's). The finite past *dug* does not seem to be attested before the beginning of the 18th c.; the *PPCEME* records *dug* in both functions in the memoirs of Celia Fiennes, completed ca. 1702. It appears that the past ptc. *dug* was created around the same time as *strung* but either spread more slowly or was resisted in written English; so far as our evidence goes, the finite past *dug* could have been a later creation. Both had become acceptable among the literate class by the end of the 17th c.

For the past of *stick* we have much more information. It is the descendant of OE *stician* 'to pierce; to adhere', whose past tense *sticode* would be expected to develop into a regular past tense *sticked*. Sure enough, a past *sti(c)ked(e)* is well attested in ME and continues to be attested in the 16th century. The *PPCEME* includes two examples, both finite pasts: *stycked* from a letter of Sir Thomas More,⁴ who was born in 1478, and *sticked* from the works of William Clowes, who was born in the early 1540's. But *stuck* is attested significantly earlier than *strung* or *dug*. The earliest attestation in the *PPCEME* is from *Ralph Roister Doister*, a play written by Nicholas Udall (born 1504) in about 1552; it is a finite past *stucke*, rhyming with *Gawyn Goodlucke* (a major figure in the play). Another seven examples, both finite past and past participle, from later in the

⁴ Also in the *PCEEC*.

century occur in the corpus.⁵ It seems clear that by the early 17th century the innovative strong forms were normal.

In the case of *stick* there is a further fact which complicates the picture. A synonymous strong verb *steke(n)* also appears in ME; it is not attested in OE,⁶ yet it appears to be cognate with Old Frisian *steka*, Old Saxon *stekan*, and Old High German *stehhan*, all meaning ‘pierce’. In late ME the past tense of this verb was *stake*, well attested in the works of Malory (also spelled *stak* and *stack*; the reconstructable pronunciation is /sta:k/), and the *OED* records a past participle *stoken* ~ *ystoke*; the inflection of the verb was precisely parallel to that of *break* (*brake*, *broken*). Just as the vowel of the latter verb’s past participle was levelled into its finite past, yielding *broke*, one would expect to find a past *stoke*, and the *OED* records such a form from the 15th and 16th centuries. However, NONE OF THESE FORMS can be the direct ancestor of *stuck*. If a form survives intact from one generation to the next, the only kind of change it undergoes is “sound change”, i.e. spontaneous changes in pronunciation. The historical record shows that sound change is overwhelmingly regular, and modern sociolinguists have identified a PROCESS of sound change that is completely regular (see e.g. Labov 1994, Fruehwald 2013). Since none of the vowels in the various forms of *steke* became /ʌ/, none of them can be the ancestor of *stuck*. Whether the existence of a synonymous inherited strong verb is relevant to the creation of *stuck* in some other way will be considered below.

5. The productivity of /ʌ/ in Early Modern English: the case of *strung*.

Making sense of the changes under consideration involves dealing with several relevant questions more or less simultaneously. We present the discussion in an order which we hope will make the situation maximally intelligible.

First of all, we need to address the complicating issue of past participles, because the situation among the past participles is not the same as the situation among the finite pasts

⁵ The *PCEEC* examples are all from the 17th century.

⁶ That is probably because it had been lost in all the OE dialects for which we have adequate attestation but survived in one or more dialects that are unattested (or nearly so). For various historical reasons the dialects of almost the whole Midlands area are unattested in the OE period.

in standard Modern English. Since finite pasts in *-ang* (*sang, rang, sprang*) correspond to past participles in *-ung* (*rung, sung, sprung*), there are actually 10 past participles in *-ung* in standard Modern English—and as the calculations in section 2 demonstrate, we might expect that to make the *ung*-rule productive for past participles. It probably is marginally productive, since *brung* does occur in nonstandard speech, but *brung* has not replaced *brought*, and past participles like “*wung*” (for *winged*) are not even attested. Since the TP otherwise accounts well for the productivity of morphological rules, there must be a specific reason for its inapplicability in this case. We might suggest that the paradigmatic relationship between the finite past and the past participle is responsible; in effect, since finite past *winged* is not under pressure from “*wung*”, neither is past participle *winged*. The great frequency of *brought* might also be a factor; so might the regularity of *winged*, etc. More research on this problem is needed, but we do not see that it has a direct impact on our investigation into the finite pasts under discussion.

Secondly, while the past participles of verbs in *-ing* in the 16th c. were essentially identical to their modern descendants (with the exception of *stringed*), the finite past tenses were not. The finite pasts *sang, sprang, rang* were in competition with *sung, sprung, rung*, and that competition was vigorous.⁷ The *PPCEME* includes twelve examples of *sang(e)* and twelve of finite past *sung* from the beginning of the 18th c. or earlier; most remarkably, their excerpts from the diary of Samuel Pepys—written by a single individual over the course of about a decade—include two of each. Though the finite past tense of *spring* is not as common, the situation is comparable: there are six examples of *sprang(e)* (ignoring a duplicate in the King James bible) and four of *sprung*. The finite past *rang* does not occur in that corpus, but *rung* occurs twice. It seems clear that for at least some speakers no fewer than ten verbs had both finite pasts and past participles in *-ung*; the only exceptions were *bring, string*, and a handful of very rare

⁷ This competition arose in the Middle English period. In Old English these verbs had two finite past stems; for instance, the indicative 1sg. and 3sg. of *singan* were *sang*, but the 2sg. was *sunge*, the plural was *sungon*, and the subjunctives were sg. *sunge*, pl. *sungen*. In the north *sang* became the only finite past in the 13th c., but further south both stems survived for another century or more, and different dialects levelled them in one direction or the other (see e.g. Brunner 1948: 76–7). London acquired both finite pasts because of the massive influx of migrants from other areas of England leading to substantial dialect mixture (Ekwall 1956).

verbs like *wing* ‘to dismember (a partridge)’. For those learners who encountered only one or two regular verbs in *-ing* other than *string*, N was 12 or 13 and there were only three or four exceptions to the *-ung* rule (*bring*, *string*, and the other regular verb(s)); in their speech the replacement of *stringed* by *strung* is exactly what the TP would lead us to expect, since a rule with twelve inputs will tolerate four exceptions and a rule with thirteen inputs will tolerate five. Even learners who heard both *sang* and *sung*, etc., as finite pasts in the speech of some adults (like Samuel Pepys) MIGHT have been moved to replace *stringed* by *strung* if the TP is not inhibited by competing forms (a question which we are not yet in a position to answer definitively, though see Sneller, Fruehwald, and Yang 2019 for suggestions).

In short, the TP actually predicts that *stringed* should have been replaced by *strung* in the 16th c. (if not before). Presumably *brought* escaped replacement by *brung* because its extreme frequency made it easier to learn and more resistant to change; rarer verbs with pasts in *-inged* were perhaps not learned during NLA, but only later in life.

However, when *sang*, *sprang*, *rang* won their respective competitions in standard English—toward the end of the 17th c., to judge from the available evidence—the *ung*-rule could no longer be productive in that dialect, because the number of finite pasts in *-ung* dropped to only 7, while the number of input verbs remained the same (or perhaps increased); as the table on p. 3 indicates, a rule with 12 inputs should not tolerate 5 exceptions ($12 - 7$), nor should a rule with 13 inputs tolerate 6 exceptions ($13 - 7$). The *-ung* rule might have remained productive in other dialects, and occasional speakers continue to produce forms in *-ung* even now, but there was no longer any chance that such forms would “catch on” in the standard language.

Innovative *strung*, then, confirms the TP simply and straightforwardly. *Stuck* and *dug* are more complicated cases.

6. *Stuck*.

While there were many verbs with finite past tenses in *-ung* in London English in the years before 1500, there were apparently none with finite past tenses in *-uck*. Therefore if *stuck* arose by productive rule, the rule must have applied to more than verbs with roots in *-ick*, and the most conservative alternative, requiring the fewest additional hypotheses,

is verbs with roots in which /ɪ/ was followed by a single velar consonant. Figuring out which such verbs were present in the speech heard by a typical native learner in, say, 1510 is probably beyond the capability of philology; we will need to employ reasonable proxies.

One plausible proxy is the collection of verbs whose finite past tenses and past participles are actually attested in the 16th- and 17th-c. samples in the *PPCEME*. Here is the list, with numbers of attestations:

brought (scores of exx., sometimes more than 10 in a single sample);
digged (11x), *picked* (7x), *pricked* (6x), *thicked* (4x, meaning ‘thickened’), *sticked* (2x), *nicked* (1x), *rigged* (1x);
sang/sung (36x), *sprang/sprung* (12x), *flung* (10x), *stung* (5x) / *stinged* (1x),⁸ *rung* (3x), *slung* (2x), *wrung* (2x).

—plus *stuck* (8x) and *dug* (3x), not present at the beginning of the period.

There are 15 verbs altogether, and only 7 follow the rule that was extended to yield *stuck* and *dug*. The natural logarithm of 15 is 2.70805, and their quotient is 5.54; the eight exceptions to the rule should therefore easily be enough to prevent it from becoming productive. However, it is plausible to suppose that not all these forms were acquired in NLA. In particular, *thicked* occurs only in discussions of the preparation of cloth (in statutes of the period) and *rigged* describes the outfitting of a ship. But removing those forms does not help much: the total is now 13, its natural logarithm is 2.56495, their quotient is 5.07, and the remaining six exceptions are still enough to prevent the “*stuck*-rule” from becoming productive.

But maybe we don’t have the right proxy. An alternative proxy would be a relevant modern list of lexemes in child-directed speech, adjusted so as to account for the differences in inflection between early 16th-c. English and present-day English. In the 6-million-word CHILDES corpus of child-directed American English⁹ a dozen relevant verbs appear in the past tense at least once each; we give them in decreasing order of

⁸ *Stinged* must be a nonce form, an outlying dialect form, or a personal idiosyncrasy; the irregular *stung* is clearly usual, and had been for some generations.

⁹ These and other classes of English verbs in the CHILDES corpus were collected and extensively used to account for English NLA in Yang 2016; see e.g. Yang 2016: 28–9, 59, 66–8 and passim.

frequency in that corpus, with their early-16th-c. past forms:

1	bring, brought	7	lick, licked
2	pick, picked	8	dig, digged
3	stick, sticked	9	swing, swung
4	sing, sang/sung	10	spring, sprang/sprung
5	kick, kicked	11	sting, stung
6	ring, rang/rung	12	fling, flung

Half of these dozen verbs had past tenses in *-ung* in the early 16th c. The natural logarithm of 12 is 2.48491, and their quotient is 4.83; thus according to the TP the six verbs in this list that have past tenses of other kinds should have been enough to prevent the formation of *stuck* in NLA, or at least to prevent it from catching on, if these verbs are a representative sample of child-directed speech in the 16th century.

In short, we cannot derive *stuck* via the application of the TP in NLA under any reasonable assumptions about what 16th-c. learners of English were hearing. It should follow that *stuck* was created by some other process, and in fact we can propose one. As we noted at the end of section 4, there was beside the weak verb *stick* (past *sticked*, ptc. *sticked*) a synonymous strong verb *steke* (*stake, stoken*; later *stoke, stoken*). It seems reasonable to suggest that some speakers—not necessarily native learners—confused the two and were therefore prompted to create a strong past and past participle for *stick*. But given that the vowel in the root of the later was /ɪ/ (throughout the word's attested history), a strong past or past participle could only be either *stack* /stak/ (which would develop into /stæk/ by regular sound change) or *stuck* /stok/ (which would develop into /stʌk/). In the event *stuck* was created in both functions and caught on. This could be called lexical analogy, though it is lexical analogy of a special kind: the influence of very similar (and in fact etymologically related) lexemes competing for position as the default representation of a meaning in the basic vocabulary.

In fact there is another piece of evidence which points in the same direction. We have not mentioned it before because it adds a further layer of complexity to the picture. We need to deal with it before we turn to *dug*.

7. *Strike / strick, past stroke / strake / struck.*

The OE verb *strīcan* ‘to stroke, to wipe; to dash, to run’ is the direct ancestor of Modern English *strike* (the meaning has evolved considerably over time). Though only the present is attested in OE, the past 3sg. can only have been **strāc* and the past participle **stricen*, parallel to *wrītan*, *wrāt*, *writen*, because the inflection of OE strong verbs with *ī* in the root is uniform. The result should have been *strike*, *stroke*, *stricken* in the 16th c., parallel to *write*, *wrote*, *written*, and in fact that paradigm is well attested. The present stem *strike* is common; perusal of about 40% of the *PPCEME* yielded 21 examples. Past *stroke* appears seven times in the same corpus, and the examples are distributed throughout the 16th c. and down to 1630. Past participle *stricken* occurs with some frequency (and survives in Modern English, though more often as an adjective than as a participle).¹⁰

But there are other forms in competition with all of the above in the *PPCEME*. There is a rare present *strick* beside *strike*. It too was a descendant of OE *strīcan*, but one in which the vowel had been shortened; that is known to have happened to a handful of class I strong verbs in some dialects of OE (Seebold 1966). One example of *strick* in the *PPCEME* occurs in the work of Thomas Harman, published in the 1560’s:

“A vaunt verlet,” quoth this vpright man, and letes dryue with all his force at this hosteler, and after halfe a dosen blowes, he *strycks* his staffe out of his hande,
(*PPCEME*, HARMAN-E1-P1, 64.7–9)

Much more surprisingly, there are two examples from John Locke’s well-known treatise on education, published in 1693. Since Locke was born in Somerset in 1632, it is possible that *strick* is a dialect form that he never abandoned, but apparently it was not stigmatized. So far as our evidence goes, *strick* persisted as a variant of *strike* in some areas, or in the speech of some individuals, into the 18th c.¹¹

It seems clear that *struck* must have been created as a past tense to *strick* in much the

¹⁰ Past participle *stroke* also occurs, e.g. in one of the Cely letters from the late 15th century and in a 17th-century letter of John Chamberlain, both in the *PCEEC*.

¹¹ The *PCEEC* seems to have only one example, from a letter of Nicholas Bacon in the second half of the 16th century.

same way that *stuck* was formed to *stick*¹²—and since *strike* / *strick* was already a strong verb, *struck* presumably replaced *stroke* and *stricken*. But already by the 16th c. the pattern of variation was more complex. The passages from Locke’s works in the *PPCEME* contain no example of a past tense or past participle of *strick*, but an online search of Locke’s works on Project Gutenberg turns up examples of *struck* in both functions, as one would expect. However, for Thomas Harman the past of *strick* was *strake*; the passage quoted above continues:

and as this hosteler stept backe to haue taken vp his staffe agayne, his glymmeringe Morte flinges a great stone at him, and *strake* him one the heade that downe hee fales, wyth the bloud about his eares,

(*PPCEME*, HARMAN-E1-P1, 64.200–1)

The past *strake* also occurs in two *PPCEME* passages from the chronicle of Robert Fabyan, who died in 1516, beside a past participle *stryken* (i.e., *stricken*); his present for this verb is not attested in the *PPCEME*, but an online search of the Open Library copy yields four examples of *stryke* (as well as many more of past ptc. *stryken*). The *PPCEME* attests both present *strike* and past *strake* from the biography of Sir John Perrott, written in the 1590’s. But many authors whose present stem is *strike* already have a past *struck*, exactly as in Modern English. The diary of Henry Machyn, written in the 1550’s and ’60’s, exhibits a paradigm *stryke*, *struck*, *stryken*. The examples of *struck* next in chronological order are from the chronicle of John Hayward, written late in the 16th c. or early in the 17th, and from a comedy by Thomas Middleton published in 1630; both are past participles. No finite past other than *struck* appears in the texts of the *PPCEME* from after 1630, though the past participles *struck* and *stricken* continue to compete in

¹² This should prompt us to revisit the first calculation in section 6, based on actually attested 16th-c. past tense forms, with *thicked* and *rigged* omitted: if *struck* was created first—a plausible scenario, given that the verb was already strong—we should add *strick*, *struck* to the verbs under consideration and recalculate. In that case *N* is 14, its natural logarithm is 2.63906, and their quotient is 5.3; but unfortunately we still have six exceptions (*brought*, *digged*, *picked*, *pricked*, *sticked*, *nicked*), and the TP still does not predict the creation of *stuck*.

general use until at least the 1660's.¹³ Samuel Pepys and Celia Fiennes both have the modern paradigm *strike, struck, struck*.

The reader who finds this picture confusing is no more clueless than we are; it seems clear enough that by the middle of the 16th c. the competition between stems of *strike / strick* could be described as a free-for-all. That is relevant because lexical analogy between *stick* and *strike / strick* is a real possibility, given the similarity of form and meaning that the two verbs exhibit: in effect, the entirely new strong past *stuck* and the remodelled strong past *struck* might have supported one another. The fact that *strike* seems to have replaced *strick* while on the other hand *struck* replaced *stroke* makes the entire situation difficult to judge. In any case there is no indication that the TP as it operates in NLA had anything to do with those developments, and once again we cannot be certain that they occurred in NLA at all; it is conceivable that adult native speakers were responsible for these innovative forms.

8. *Dug*.

The pattern of evidence suggests, though it does not quite establish, that *dug* was created later than either *struck* or *stuck*; it might or might not have been created later than *strung*. Let us therefore revisit the first calculation under section 6 (again; see fn. 12), with *thicked*, *rigged*, and *stinged* (see fn. 8) excluded but *struck* and *stuck* included. We have the following set of relevant forms for native learners who hear *strick* in use:

brought;

digged, picked, pricked, nicked;

sang/sung, sprang/sprung, flung, struck, stuck, stung, rung, slung, wrung.

In this case N is 14, its natural logarithm is 2.63906, and their quotient is 5.3; since we have only five exceptions to the rule “replace /ɪ/ with /ʊ/”, we expect the rule to be productive. The only surprise is that *digged*, the commonest regular verb of this set in our sample, has been targeted for replacement; that will have to be laid to contingent factors no longer recoverable. For native learners hearing *strike* in use, we will have to omit *struck* from the above list; N is then 13, its natural logarithm is 2.56495, their

¹³ Forman's diary, which covers the second half the 16th c., yields a variant *stroken*. Past *strake* and past participle *strucken* occur several times in a wide range of letters in the *PCEEC*, adding to the picture of extensive variation in several dimensions.

quotient is 5.07—and we still have only five exceptions to the rule, which should therefore be productive even for these learners.

In short, if *dug* was the last of these innovative forms to be constructed, the TP predicts its appearance. Moreover, just as the victory of *sang*, *sprang*, *rang* late in the 17th c. explains why *winged* was not replaced by “*wung*”, it also explains why *rigged* did not yield to “*rug*”—nor *picked* to “*puck*”, and so on, in accordance with the TP. Note that the verbs in *-ick* which entered English after the victory of *-ang* over *-ung* have all remained regular; to judge from the OED entries, they include at least *click*, *flick*, *tick*, and *trick*. Finally, the fact that the calculations in this section worked out so neatly suggests that a list of forms most frequently attested in non-specialized texts is a reasonable proxy for the unobtainable list of input forms for NLA in centuries long past. Of course that cannot be proved, but it is at least a construct *où tout se tient*.

9. Looking forward.

The results just described are clear-cut enough and interesting enough to prompt testing of the TP against other instances of past tense “irregularization” in English. While a full study of any of the relevant verbs is beyond the scope of this paper, two cases seem clear enough that suggestions might be useful.

The replacement of *dived* by *dove* in 19th-c. North American English appears to be easily explainable by the TP. So far as we can discover, only four verbs in *-ive* were common enough to be learned regularly by small children at that time and place;¹⁴ their finite pasts were:

drove, *strove*;

throve ~ *thrived*;

dived.

In addition, there were two verbs of more specialized meaning, whose finite pasts were:

hived (*bees*), *rived* (*cedar shakes with a froe*).

Even if small children learned the specialized verbs, pasts in *-ove* could have become productive in the NLA of those learners who heard *throve*, according to the table in section 3; for children who did not learn the specialized verbs early, the *-ove* rule could

¹⁴ *Shrive* and *swive* were no longer in everyday use; *jive* had not yet been coined.

have become productive even if they heard *thrived*. Thus the TP easily predicts the appearance of *dove*.

A contrary case is *hung*. Like *strike, struck* (see section 7), *hang, hung* (transitive) has been a strong verb throughout its history, but its finite past is not the one that is expected etymologically. To judge from the citations in the OED, *hung* might first have appeared in the 16th c.; on the other hand, some of the Middle English finite pasts spelled *hong(-)* might conceivably have contained /ʊ/ in the root. This case requires a thorough study in detail. However, it is already clear that the verb had several competing finite pasts in Middle English, and it would be reasonable to wager that the history of *hang* will turn out to be much like that of *strike*—not involving NLA nor the TP.

There is also a relatively recent phenomenon that seems to be different from both the phenomena dealt with in this paper. A finite past *snuck* (to *sneak*) first appears in the USA in comic writing in the mid-19th c.; William Faulkner, toward the end of his short story “Was”, has a character say *you skun the hen-house one time too many*; Dizzy Dean is quoted as having said *he slud into third*;¹⁵ a collection of oral histories of D-Day includes the statement *those that were wounded we drug up behind* (Astor 1994: 196); and a finite past *rutch* (to *reach*) was heard at a sporting event at Pennsylvania State University (Philip Baldi, p.c.). It seems clear that /ʌ/ is spreading as a finite past tense vowel for irregular verbs in North American English, but it is not clear exactly what is going on, nor why regular verbs occasionally acquire such finite pasts. Those topics must be left for future research.

10. Conclusion.

A close examination of the “irregularization” of verbs in Early Modern English confirms the usefulness of the tolerance principle in predicting which morphological rules will become productive. It also shows that the tolerance principle is not the whole story, as might have been expected. It appears that situations in which synonymous and similar but differently inflected verbs, such as *steke* and *stick*, are in competition can lead to unexpected results; competition between multiple stems of a single verb, as in the case of *strike / strick*, can also yield unforeseen anomalies. It is very likely that lexical

¹⁵ We are grateful to Patrick Stiles for calling this to our attention.

analogy plays a part in these latter developments, and that adult native speakers are responsible for those innovative forms.

References.

- Albright, Adam, and Bruce Hayes. 2003. Rules vs. analogy in English past tenses: a computational/experimental study. *Cognition* 90(2): 119–61.
- Astor, Gerald. 1994. *June 6, 1944: the voices of D-Day*. New York: St. Martin's.
- Berko, Jean. 1958. The child's learning of English morphology. *Word* 14: 150–77.
- Brunner Karl. 1948. *Abriss der mittelenglischen Grammatik*. 2nd ed. Halle: Niemeyer.
- Ekwall, Eilert. 1956. *Studies on the population of medieval London*. Stockholm: Almqvist & Wiksell.
- Fruehwald, Josef. 2013. *Phonological influence on phonetic change*. Dissertation, U. of Pennsylvania.
- Kroch, Anthony, Beatrice Santorini, and Lauren Delfs. 2004. *The Penn-Helsinki parsed corpus of early Modern English*. Philadelphia: Dept. of Linguistics, U. of Pennsylvania.
- Labov, William. 1994. *Principles of linguistic change*. Vol. 1. *Internal factors*. Oxford: Blackwell.
- MacWhinney, Brian. 2000. *The CHILDES project: tools for analyzing talk*. 3rd ed. Mahwah, NJ: Lawrence Erlbaum Associates.
- Nevalainen, Terttu, et al. 2006. *The parsed corpus of early English correspondence*. Text version. Helsinki: U. of Helsinki.
- Nida, Eugene. 1949. *Morphology: the descriptive analysis of words*. 2nd ed. Ann Arbor: U. of Michigan Press.
- Pinker, Steven. 1999. *Words and rules: the ingredients of language*. New York: Basic Books.
- Seebold, Elmar. 1966. Die schwundstufigen Präsentien (Aoristpräsentien) der *ei*-Reihe. *Anglia* 84.1–26.
- Sneller, Elizabeth, Josef Fruehwald, and Charles Yang. 2019. Using the Tolerance Principle to predict phonological change. *Language Variation and Change*, in press.
- Xu, Fei, and Steven Pinker. 1995. Weird past tense forms. *Journal of Child Language*

22(3): 531–56.

Yang, Charles. 2016. *The price of linguistic productivity: how children learn to break the rules of language*. Cambridge (MA): MIT Press.

Yip, Kenneth, and Gerald J. Sussman. 1997. Sparse representations for fast, one-shot learning. *Proceedings of the National Conference on Artificial Intelligence* 521–7.