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DOI

[10.1515/flih-2019-0008](https://doi.org/10.1515/flih-2019-0008)

Publication date

2019

Document Version

Final published version

Published in

Folia Linguistica

[Link to publication](#)

Citation for published version (APA):

Adamczyk, E., & Versloot, A. P. (2019). Phonological constraints on morphology: Evidence from Old English nominal inflection. *Folia Linguistica*, 40(1), 153-176.
<https://doi.org/10.1515/flih-2019-0008>

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Phonological constraints on morphology: Evidence from Old English nominal inflection

<https://doi.org/10.1515/flih-2019-0008>

Received June 17, 2018; revised December 4, 2018; accepted December 17, 2019

Abstract: Studying the complex interaction between phonological and morphological developments involved in the extensive reorganisation of nominal inflection in early English, we focus, primarily, on new inflectional endings that emerged by analogy in etymologically suffix-less paradigm forms of *r*-stems and root nouns. We argue that the analogical changes were essentially reactive to phonological developments, and to a large extent predictable in statistical terms. Investigating correlations in corpus data, we identify the factors that affected the probability that new analogical endings were adopted. The predictors of the directions of analogical change that we show to be robust include the syllable structure of the root, the salience of inherited and analogical inflectional markers, as well as their absolute and relative frequencies.

Keywords: inflectional morphology, frequency, syllable structure, salience, multivariate analysis

1 Introduction

The interplay between sound change and morphological analogy has been traditionally framed in terms of ‘Sturtevant’s paradox’ (Sturtevant 1947: 109): sound change, which is inherently regular, produces irregularities, while analogical change, which is irregular, produces regularity. Analogical changes are seen as reactive to phonological developments and thought to occur after them (e.g. Paul 1886: 181). They eliminate allomorphic variation when it is produced by sound change (cf. Antilla 1977; Hock 2003; Campbell 2004; Ramat 2012; Fertig 2013). In the paradigm of OE *céos-an* ‘choose’, for example, Verner’s Law (changing intervocalic /s/ to /z/) and rhotacism (changing /z/ to /r/) had

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produced the past plural form *cur-on* (<PGmc **kuzum*) ‘we/they chose’ as opposed to singular *céas* ‘I chose’. Analogy then re-established uniformity among past-stems, yielding ME *chose* (SG) – *chosen* (PL). Thus, sound change and analogy have been viewed as two opposing forces involved in a cause-and-effect relation. This view has gained widespread approval and has been questioned only occasionally, most notably by Schuchardt (1885), who does not see the two processes as opposing forces since they often work in the same direction (Fertig 2013: 97).

Of course, many languages show developments that seem to fit the pattern captured in Sturtevant’s paradox, but closer scrutiny often reveals that the relations between sound changes and morphological changes – including analogical levelling – are not that straightforward. More recent studies on analogy have therefore refined the picture. Hock (2003: 457), for example, points out that “sound change typically is regular, and morphologically or semantically motivated analogy typically is irregular; but phonologically motivated analogy [...] tends to be as regular as sound change, and changes such as dissimilation and metathesis require a general phonological motivation to become regular” (cf. Fertig 2013: 96–98).

Phonological and morphological developments in early Germanic languages also seem to have interacted in ways that were more complex than Sturtevant’s paradox suggests. In particular, the operation of analogy does not seem to have been irregular or chaotic at all. Instead, it is quite predictable, although it follows probabilistic rather than categorical rules that involve multiple factors. We demonstrate this with a case study of Old English nominal inflection, where analogical changes resulted in a large-scale regularisation of nominal inflectional paradigms. These analogical changes affected and replaced many forms that had resulted from the application of regular sound changes. However, the inflectional profiles that ultimately emerged in the paradigms were still largely determined by their phonological makeup, which could trigger or block analogical reshufflings.

Two phonological tendencies played a central role in the restructuring of nominal paradigms in Old English: (a) the more or less consistent presence of *i*-mutation in certain minor classes (root nouns like *fōt* – *fēt* ‘foot’, or monosyllabic *nd*-stems like *frēond* – *frīend* ‘friend’), and (b) the attrition of vowels in unaccented syllables. The latter reduced the Proto-Germanic inventory of unstressed vowels to only four in Early Old English, and all of them reduced to *schwa* in Late Old English. As a result of these changes, in many paradigms, formerly distinctive inflectional endings were either lost or became syncretic. This motivated *interparadigmatic* analogies, which restored some of the lost distinctions. Table 1 shows the effects of interdeclensional realignments in the paradigm of the OE *r*-stem *brōþor* ‘brother’. Six out of eight forms in the archaic

Table 1: The competing inflections in the masculine *r*-stem paradigms.

	archaic		innovative	
	SG	PL	SG	PL
NOM	<i>brōþor</i>	<i>brōþor</i>	<i>brōþor</i>	<i>brōþ(o)r-u, -as</i>
GEN	<i>brōþor</i>	<i>brōþr-a</i>	<i>brōþ(o)r-es</i>	<i>brōþra</i>
DAT	<i>brēþer</i>	<i>brōþr-um</i>	<i>brōþ(e)r-e</i>	<i>brōþr-um</i>
ACC	<i>brōþor</i>	<i>brōþor</i>	<i>brōþor</i>	<i>brōþ(o)r-u, -as</i>

paradigm end in zero, and one of them had an irregular *i*-mutated stem. In the innovative paradigm, on the other hand, stem-uniformity was restored: four out of the six forms received new and distinctive endings by analogical transfer from other classes.

As the morphological restructuring unfolded, however, phonology came once again into play: as we shall show, the phonological shape of the lemmas, including their syllable structure, had a considerable impact on the likelihood of specific forms to undergo analogical levelling.

The present study investigates various factors that conditioned the reorganisation of Old English nominal inflections. They include (1) absolute and relative frequency of occurrence/use, (2) the morpho-phonological salience of inflectional exponents, (3) the functionality of morphological forms, and (4) phonological structure. We show that the attested inflectional profiles of the nominal paradigms emerged from a complex interplay among these conditioning factors, whose effects could either enhance or neutralise one another. In order to explain this interaction, the study applies a multifactorial statistical analysis, in which the factors just mentioned function as independent variables (cf. Versloot and Adamczyk 2018). Our particular focus will be on the way in which the phonological form of words constrained or motivated analogical developments.

2 Patterns of analogical reorganisation of the Old English nominal inflection

2.1 Major tendencies of reorganisation

The reorganisation of Old English nominal inflection resulted from two types of analogy: *intraparadigmatic* levelling and *interparadigmatic* transfer.

Intraparadigmatic levelling reduced allomorphy within paradigms, for example, by eliminating *i*-mutated vowels and replacing them with unmutated vowels from other forms (as in the DAT.SG of root nouns like *fēt* → *fōte* ‘foot’ and especially in the NOM/ACC.PL of *s*-stems like *calfur* → *calfas*). Levelling also eliminated consonantal alternations (e.g. in *s*-stems like *lamb* NOM/ACC. SG – *lambor* → *lamb* NOM/ACC.PL ‘lambs’, but also in root nouns and dental stems). Thus, it rendered paradigms more uniform and made them more susceptible to *interparadigmatic* analogical transfer, facilitating the attachment of new inflections. These were transferred mostly from major (productive) classes (i.e. from *a*- and *ō*-stems) to minor (unproductive) ones (i.e. *i*-, *u*-, *s*-, *r*-, *nd*-, *þ*-stems and root nouns).

The reorganisation of the English nominal system had begun at the prehistoric stage and continued in the historical period. Prehistoric developments had led to an extension of the GEN.PL (-*a*) and DAT.PL (-*um*) forms. In many minor paradigms, these endings did not reflect the original forms but were taken over, by analogy, from the expanding masculine (and neuter) *a*-stems and feminine *ō*-stems (e.g. Campbell 1977: 252, 258; Hogg and Fulk 2011; Adamczyk 2018: § 3.6). A similar early influence of productive inflections is identifiable in the GEN.SG in masculine stems, which shows little variation, and the productive *a*-stem marker -*es* came to be the predominant form in nearly all declensional classes (e.g. *u*-stem *flōres* ‘floor’, root noun *fōtes* ‘foot’, *s*-stem *cealfes* ‘calf’, *nd*-stem *frēondes* ‘friend’; Adamczyk 2018: 170, 179, 184, 204, 217).

Prehistoric phonological developments affected light- and heavy-syllable stems in different ways, and produced diversity among inflectional paradigms. This refers in particular to the West Germanic loss of vowels in final unstressed syllables: short vowels were lost only after heavy syllables, while long vowels were shortened after both light and heavy syllables (Boutkan 1995: 39–42).¹ These developments are particularly relevant for paradigm restructuring in the *i*-stems, *u*-stems and root nouns, where the process unfolded differently in light-syllable and heavy-syllable stems: in the NOM/ACC.SG of light-syllable nouns (such as *dur-u* ‘door’), the original vocalic markers were retained, whereas they were lost in the NOM/ACC.SG of heavy-syllable nouns (such as *hand-Ø* ‘hand’, *feld-Ø* ‘field’), which took a zero marker, and consistently ended in consonants. In that respect, heavy-syllable nouns in the minor classes became indistinguishable from the productive *a*- or *ō*-stem nouns (such as *stān* ‘stone’, or *wund* ‘wound’), which explains why heavy-syllable stems tended to be more easily and earlier affected by analogical transfer.

¹ Cf. NOM.SG *wine* (LL)_F ‘friend’ <PWGmc. **wini* (LL)_F versus *dæd* (H)_F ‘deed’ <PWGmc. *dādi* (H)_FL; DAT.SG *wine* (LL)_F <PWGmc. **wini* (LH)_F versus *dæde* (H)_FL <PWGmc. *dādī* (H)_FH (Hogg 2011: 220; 222–223; Smith 2007).

In the historical period, (originally) minor class nouns came to assume mostly inflections from the two dominant classes, masculine *a*-stems and feminine *ō*-stems. The *n*-stem inflections, such as the GEN.PL *-ena* (as in *ox-ena* ‘ox-GEN.PL’) or the NOM/ACC.PL *-an* (as in *ēag-an* ‘eye-NOM/ACC.PL’), although potentially productive, were taken over only very rarely (less than 5%) at this early stage (Adamczyk 2018: 166–167, 174; 180; 193, 225). Gender was consistently preserved at first, and accordingly masculine nouns followed the masculine *a*-stem pattern and feminine nouns the feminine *ō*-stem pattern. Once the gender system became unstable at the beginning of the Middle English period, the *a*-stem pattern came to prevail.

Crucially, analogical transfer operated on individual case-and-number endings and did not directly transpose entire inflectional paradigms. This means that nouns did not change their class affiliation in a single step, but gradually adopted one analogical inflection after the other. This led to the emergence of ‘mixed paradigms’, which contained both inherited inflections and analogical ones (Adamczyk 2018: § 8.4).

2.2 Interaction of morphology and phonology in analogical realignments in Old English nouns

Phonological and morphological changes can interact in several different ways. Potential scenarios of interaction in the area of early Germanic nominal inflection include the following:

- (1) The regularisation of a paradigm may be favoured and induced by phonological constraints. An example is the introduction of final *-u* in the NOM.SG of light-syllable feminine root nouns, such as OE *hnutu* ‘nut’, from the feminine *ō*-stems (as *faru* ‘journey’) or *u*-stems (as *duru* ‘door’). This transfer was motivated by metrical preferences, producing a quantity-sensitive, left-to-right resolved moraic trochee, which is a preferred structure (Dresher and Lahiri 1991: 251).² A similar case is regularisation that involves phonological properties of the root. It is manifest in analogical levelling affecting the singular forms of feminine *i*-stems (OE *dryht* ‘army’,

² According to Hogg and Fulk (2011: 68), the attested endless forms are a result of apocope rather than a continuation of the original inflectional pattern. The major problem with this phonological interpretation and an argument in favour of treating them as inherited is the early date of the sources in which they are found, i.e. the eighth century (ErfGl(2), CollGl(3)). An exception is the form *durustod* (*dorstod*) (ClGl1), which is attested later (mid-10th c.), and thus its status as an original form may indeed be disputed.

ēst ‘favour, grace’, OFris. *dēde* ‘deed’, *kest* ‘statute’), which were originally endingless in the NOM/ACC.SG, and had *-e* in the GEN/DAT.SG. In stems that ended in voiced consonants (such as *dēd*), the final *-e* tended to be generalised in all singular case forms,³ while in stems that ended in voiceless consonant clusters, the *-Ø* ending from the NOM/ACC.SG was extended to the GEN/DAT.SG. These developments clearly reflect the impact of a preference for final consonants to be voiceless and for medial ones to be voiced (cf. Adamczyk 2018: 154).

- (2) Phonological constraints on metrical structure may block morphologically-motivated regularisation. This is evident in heavy-syllable root nouns (OE *fōt*-[*e*], *neah*-[*e*]), which adopted the *a*-stem/*ō*-stem DAT.SG marker *-e* only sporadically, while light-syllable nouns did so consistently. Likewise, the DAT.SG *a*-stem marker *-e* was adopted only sporadically in disyllabic *s*-stems such as *hrīðer*-(*e*) ‘cattle-DAT.SG’ (< OE *hrīðer* < PGmc. **hrinþeri*), but consistently so in monosyllabic stems such as *lamb*-*e* ‘lamb-DAT.SG’.
- (3) Phonologically induced changes can enhance morphological contrasts, rather than increase irregularity, by introducing allomorphic variation into the paradigm. This applies to (a) *i*-mutation (e.g. OE *mūs* ‘mouse’ : *mȳs*, *brōc* ‘breech’ : *brēc*) and (b) consonantal alternation, involving the *r*- and *p*-formatives (e.g. OE *æg* ‘egg’ : *ægru*, *cealf* ‘calf’ : *cealfru*, *cild* ‘child’ : *cildru*, *hæle* ‘hero’ : *hæleð*) as (potentially) salient plural markers in certain declensional classes (root nouns and *s*-stems).

The impact of phonological factors can be modified by other factors, such as frequency and functionality of paradigmatic forms. Frequency, for instance, plays a role in the pattern of elimination/retention of the *r*-formative in the *s*-stems (OE *lambor*, *hrīþer*; OFris. *clāthar*, *hrēther*). The loss of the *r*-formative in the NOM/ACC.SG is confined to highly frequent nouns (cf. Versloot 2014). Functionality in turn explains why *i*-mutated vowels were eliminated from the paradigm of root nouns more easily in the DAT.SG than in the NOM/ACC.PL, where *i*-mutation continued to signal a functional distinction, namely the SG–PL contrast.

³ For Old English, this tendency applies to the GEN/DAT.SG but not to the NOM.SG. Additionally, the distribution of the final *-e* depends on the relative frequency of individual categories (NOM/ACC.SG vs. GEN/DAT.SG; see Section 3.2).

3 Case study: Archaic endingless forms in *r*-stems and root nouns

3.1 The morphological profile of *r*-stems and root nouns

As indicated, the present case study focuses on two minor declensional classes, i.e. *r*-stems and root nouns. They are both unproductive and contain few word types, which are, however, highly token-frequent (e.g. *man*, *fæder*, *burg*). Their paradigms exhibit morphophonemic alternations: *i*-mutated vowel in the NOM/ACC.PL (root nouns) and GEN/DAT.SG (primarily root nouns), e.g. *gēs*, *brēþer*. The inherited paradigms lacked explicit inflectional markers in the SG and in the NOM/ACC.PL, but came to adopt new ones by analogical transfer. This allows us to focus exclusively on suffix adoption, without having to consider the competition between different suffixes as well. In terms of root structure, all root nouns were monosyllabic, and either light (*hnut* ‘nut’, *stud* ‘pillar’) or heavy (*fōt*, *neaht*, *burg*). The *r*-stems, on the other hand, were exclusively disyllabic (*fæder*, *brōþor*, *dohtor*, *mōdor*, *sweostor*).

Table 2 shows the inclination of root nouns and *r*-stems to adopt suffixes from the productive classes in singular and plural forms. The data derive from a systematic comparative study of nominal inflection in the early Northern West Germanic languages (Adamczyk 2018).⁴ The focus of the quantitative analysis was on the incidence of inherited vs. analogical forms in the minor (unproductive) stem paradigms.

The diverse levels of innovation attested in the paradigms of individual minor classes result from the interplay of various factors, such as frequency, salience of inflectional markers, and the phonological shape of lemmas. The impact of salience is most prominent in the NOM/ACC.PL of root nouns, where the inherited *i*-mutated vowels constituted stable inflectional markers, resistant to analogical pressure from other declensions. That conserving effect was strengthened by (relative) frequency, as root nouns tended to appear more

⁴ The investigation was conducted on the complete collection of the Old English texts from the *Dictionary of Old English* Electronic Corpus (DOEC) (Healey et al. 2009). Not all categories were relevant for the estimation of the scope of analogical levelling; this refers in particular to the forms of the NOM/ACC.SG and GEN/DAT.PL, which formally overlap with the forms from the productive paradigms. The figures for the masculine root nouns exclude the occurrences of *mann*, whose token frequency was much higher than of the other nouns in this class, and their inclusion would be likely to skew the results. Likewise, the analysis of the inflection in *fæder* was limited to all attestations classified as *Early* and *Indeterminate* in the DOEC, and a selection of data from the Late Old English period (ca. 2500 occurrences).

Table 2: The percentage of new forms in the paradigms of OE root nouns and *r*-stems.

	<i>r</i> -stem (m)	<i>r</i> -stem (f)	root nouns H (f)	root nouns L (f)	root nouns H (m)
NOM.SG	—	—	—	87% (30)	—
GEN.SG	23% (647)	5% (292)	82% (459)	50% (2)	95% (22)
DAT.SG	3% (771)	2% (347)	26% (1648)	33% (12)	18% (66)
ACC.SG	—	0% (499)	3% (923)	11% (9)	—
NOM/ACC.PL	73% (526)	64% (97)	8% (645)	14% (14)	3% (685)

frequently in the plural than nouns in other classes. Salience of the innovative endings, on the other hand, explains why masculine *r*-stems adopted new GEN. SG endings more often than feminine *r*-stems. The *-es*, adopted by 23% of masculine forms, was more salient than the *-e*, adopted by only 5% of feminine forms. Section 3.2 discusses potential conditioning factors in detail, and Section 4 subjects them to statistical analysis, where their share in the analogical restructuring is computed.

3.2 Potential conditioning factors

We hypothesised the following conditioning factors to have potentially affected the restructuring of minor paradigms: (1) frequency, (2) the salience of inflectional exponents, (3) functional factors, and (4) phonological structure (syllable structure, stem weight).

3.2.1 Frequency of occurrence/use (token frequency and relative frequency)

The relevance of frequency for language structure and language change has been demonstrated in many studies (e.g. Greenberg 1966; Bybee 2007, Bybee 2010; Diessel 2007; Haspelmath and Sims 2010). The effects of frequency depend on the linguistic level they are manifested at. High (token) frequency can lead to phonological reduction, but also to the preservation of morphological structure. This means that frequent items are more likely to be phonologically reduced, but at the same time more resistant to analogical pressures. Thus, highly frequent nouns will tend to preserve inherited inflectional patterns longer, whereas infrequent nouns will tend to succumb to analogical pressure from productive patterns.

Frequency effects can involve different types of frequency: (a) the frequency of specific paradigm forms, e.g. NOM/ACC.SG vs. GEN/DAT.SG, (b) the frequency of all word-form tokens of a lemma, (c) the frequency of a specific paradigm/scheme (type frequency) and (d) the relative frequency of different sets of forms of a word (e.g. SG vs. PL). Two of these frequency types are particularly relevant for the present study, namely the frequency of specific paradigm forms and the relative frequency of SG and PL forms.⁵

The frequency of a specific paradigm form (i.e. case/number form) reflects the interaction of extra-linguistic factors and the features of a linguistic system. Grammatical categories can be hierarchically ordered according to their frequency (Greenberg 1966). For case marking, this yields the following hierarchy: nominative > accusative > dative > other (Hawkins 2004: 64–68). Distinctions in lower positions on the hierarchy tend to erode before those in higher positions; thus, low frequency categories such as the GEN.PL and DAT.PL are more prone to the impact of analogy than the NOM.SG. The different shape of case endings also shows how high token frequency leads to phonological erosion and stabilises phonological shortness. That highly frequent NOM/ACC.SG forms are marked by zero is predictable from that perspective, as is the fact that low frequency categories such as the GEN and DAT tend to be explicitly marked (cf. Haspelmath's (2008) notion of *predictability*).

Relative frequency, in our case the proportion of plurals, affects the analogical pressure of either of the two forms (SG or PL) on the other. Its extreme manifestation is found in the occasional analogical extension of plural forms to the singular paradigm in nouns with high plural proportions. This has been described in qualitative terms by Tiersma (1982) and defined as “local markedness” (cf. *brōc* : *brēc* PDE *breech*; Tiersma 1982: 835; cf. Haspelmath 2006). High relative frequency can under specific (extreme) circumstances lead to lexicalization, e.g. modern High German *Stätte* ‘place, location’, derived from the DAT.SG (i-mutated) form of *Stadt* ‘town, place’ (OHG NOM.SG *stat* – DAT.SG *stetti*), or PDE *brethren* ‘members in a congregation’, originally an irregular plural form of *brother*, with the ending *-en* extended from the productive *n*-stem inflection in Middle English.

3.2.2 Saliency of inflectional exponents

Saliency involves two components: (a) phonological saliency and (b) morphological complexity. Phonological saliency is defined in terms of acoustic weight

⁵ Most nouns in the two declensional classes are relatively frequent – which was a precondition to survive at all from Proto-Germanic with these non-productive inflectional patterns. At the same time, both classes are small in terms of type frequency.

and perception. It depends on three factors: (a) the number of phones in the morpheme (phonetic substance), (b) the presence or absence of a vowel (syllabicity), and (c) the total sonority of the morpheme (Goldschneider and DeKeyser 2001: 22–23). Sonority is established by the *sonority hierarchy* (Goldsmith 1990: 110; Selkirk 1984; Hooper 1976; cf. Jespersen 1904: 186), where each level is assigned a value. Low vowels are most sonorous and voiceless stops are least sonorous.⁶ Accordingly, zero endings are less salient than V-endings, which in turn are less salient than VC-endings. We hypothesise that (a) more salient inflectional markers will be more resistant to analogical pressure than the less salient ones, and that (b) analogical pressure from more salient markers will be higher than from the less salient ones.

The other component of salience is morphological complexity, i.e. the complexity of inflectional exponents. The preference for the type of marker correlates with its position in a complexity hierarchy of morphological marking (here of case/number exponency). Various parameters of morphological complexity have been identified (Dammel and Kürschner 2008: 248–256; Wurzel 1990: 139; cf. Corbett et al. 2001: 212–214), but only two are relevant for our purposes, namely (1) stem involvement, and (2) zero expression. Combining phonological and morphological complexity criteria, we order Old English case/number exponents on the complexity scale in Figure 1.

Figure 1: The combined salience and complexity scale of inflectional marking (Adamczyk 2018: 56).

Zero marking is least salient on both phonological and morphological grounds. Suffixes that consist only of vowels are less salient than suffixes consisting of a combination of a vowel and a consonant, and suffixes containing a nasal /n/ are less salient than those containing a fricative /s/. More salient than suffixation is consonantal stem modulation. It encompasses both synchronically transparent and obsolete alternations. The latter involve consonantal alternation in the

⁶ The following assumptions are involved: (a) the more phones in a functor, the more perceptually salient it should be; (b) functors containing a vowel in the surface form should be more perceptually salient than those without a vowel; (c) functors that are more sonorous should be more salient than those that are less sonorous (Goldschneider and DeKeyser 2001: 22–24).

s-stems and dental stems, whose markers *-(e)r* and *-eþ* (as in OE *lomb* : *lombor* ‘lamb’ or OE *hæle* : *hæleþ* ‘hero’) are historical stem formatives, but were reanalysed as part of inflectional suffixes in Old English. These consonantal alternations stay in contrast with ‘genuine’ consonant stem modulation, as in OE *brōc* /k/ : *brēc* /tʃ/ ‘breech’ (in the DAT.SG and NOM/ACC.PL), which are, however, rare in Old English and have no independent morphological function. As regards vocalic stem modulation, what is relevant here is *i*-mutation, which we consider to represent the most salient exponent of inflection.

3.2.3 Functional factors

One of the essential contrasts endangered by phonological developments was the contrast in number. As opposed to case inflection, number inflection counts as ‘inherent’, i.e. it encodes a morpho-semantic function, and is not purely syntactically conditioned (Booij 1996: 2). Lack of number distinction is therefore more highly dispreferred than lack of case distinction, and it tends to be re-established when it gets lost. In English, the singular–plural distinction was undermined in the first place by syncretisms of the NOM/ACC.SG and NOM/ACC.PL that had resulted from vowel reduction and loss in inflectional syllables. In the *r*-stems, for example, etymologically endingless NOM/ACC.PL forms had come to overlap with NOM/ACC.SG forms (cf. Table 1). The introduction of the masculine *a*-stem plural marker *-as* and the feminine *ō*-stem marker *-a* restored the singular/plural contrast. Our data attest to widespread innovation in the NOM/ACC.PL (see Section 3.1, Table 2), with analogical endings extended from the *a*-stems (masc.) and *ō*-stems (fem.). All these changes helped to maintain the crucial number opposition (NOM.SG vs. NOM.PL) in the declensional system.

Note that analogical transfer of explicit plural markers is also a predictable frequency effect (see Section 3.2.1 above). Plurals are normally less frequent than singulars, and therefore tend to be less resistant to analogical levelling. Below, we use statistical methods to investigate the relative importance of low frequency and high functionality for analogical innovation in plural marking.

3.2.4 Phonological structure

The *r*-stems contained only disyllabic nouns, and all root nouns were monosyllabic. Table 3 shows which combinations of light and heavy syllables are attested in monosyllabic root nouns and disyllabic *r*-stems, as well as how syllable weight was quantified. Essentially, we followed a simple, but widely shared practice:

Table 3: Old English word structure.

Example	Rhyme structure	Overall syllable weight of the root
<i>brō-þer, doh-ter</i>	VV + V(C), VC + V(C)	2 + 1 = 3
<i>fæ-der</i>	V + V(C)	1 + 1 = 2
<i>gōs, burg, cū</i>	VV(C), VC(C), VV	2
<i>stud, hnit</i>	V(C)	1

short vowels and consonants in a rhyme count 1, long vowels and diphthongs count 2, and word final consonants count 0 (they are extrametrical).⁷

Type xVC (as in *stud*) is the lightest one. Since major class items are likely to be stressed in utterances, very light lexical monosyllables are marked, because stress is usually associated with weight.⁸ This makes items of the *stud* type relatively likely to receive a second syllable by morphological analogy. The same follows from the word isochrony principle (Nooteboom and Cohen 1995: 168). It is based on the observation that words tend to be(come) similar in terms of their acoustic duration, regardless of their internal segmental and syllabic structure. Although it is still controversial if word isochrony was relevant in older Germanic languages,⁹ the principle predicts that light-syllable words (such as

7 The methods of counting and the interpretations of the concepts of ‘heavy’ and ‘light’ syllables vary widely among scholars, ranging from the application of concepts such as mora, foot, extrametricality (e.g. Dresher and Lahiri 1991; Minkova and Stockwell 1994; Smith 2007; Goering 2016) to a postulation of a weight-mapping typology involving an interaction of categorical and gradient constraints (Ryan 2011).

8 This correlation is not absolute, as observed by Minkova and Stockwell (1994: 37), but manifests itself on various occasions in the history of Germanic languages, for instance, in Open Syllable Lengthening in West Germanic (Lahiri and Dresher 1999) or in Scandinavian quantity shifts (Kusmenko 2005).

9 In older Germanic languages, the primary unit of rhythm and isochrony may have been the syllable rather than the word (e.g. Szczepaniak 2007a). This seems to follow from the presence of vowel harmony processes, which correlate typologically with syllable-based rhythm, low syllabic complexity, and other syllable-related phenomena (cf. Szczepaniak 2007b: 58; cf. Auer 1993: 102). In Old English, however, the results of the ‘harmonic’ interactions between adjacent syllables, such as *a*-umlaut, *i*-umlaut, retraction of **a* before back vowels, back mutation and breaking, had already been phonologised as distinctive root vowel qualities by the time of the first attestations. Therefore, Old English seems to have been moving away from syllable-type metrics already, and towards word-based metrics. This corresponds to a similar trend on the morphological level, where the shift from stem- to word-based inflection is considered to have occurred already in the pre-Old English period (Kastovsky 1995: 228). In contrast, the Continental Germanic languages tended to preserve the stem-based type of inflection longer (e.g. Harnisch 2001).

stud) will add phonological substance more readily than heavy-syllable words (such as *gōs*).

4 Statistical analysis of factors affecting the probability of analogical suffix addition

4.1 Description of the method and the actual model

We applied statistical regression modelling to investigate how the factors discussed in the previous section affected the likelihood that suffixless word forms of *r*-stems and root nouns adopted suffixes from major classes by analogy. Our particular focus was on phonological structure. The input for the analysis was a set of 11,776 tokens from historically suffixless Old English *r*-stems and root nouns. It includes all attested forms except those in the GEN and DAT.PL, which ended in *-a* and *-um* respectively. Additionally, some archaic forms show *i*-mutated root vowels in the DAT.SG and NOM/ACC.PL. From the set of factors discussed in Section 3, a subset was selected to serve as independent variables. The case-number ending served as the dependent variable. In archaic forms it was zero (coded as '0'), in innovative forms it was an analogically transferred suffix (coded as '1'). Each token in the dataset constituted a single observation. Our logistic regression model tested whether and to what extent an independent variable contributed to the selection of either of the two alternatives, always taking the impact of the other variables (factors) into account. The calculation was made by means of the online calculator *Logistic Regression* by John C. Pezzullo (cf. Hosmer and Lemeshow 1989), available at: <http://statpages.info/logistic.html>.

4.1.1 Phonological variables involving word structure

In our analysis, we considered two phonological properties of roots: (a) the number of syllables in a form (*syll*) and (b) their total syllabic weight (*rw*). Nouns such as *brōþer*, 'brother', *fæder* 'father' and *hnutu* 'nut' count 2 syllables, while nouns like *gōs* 'goose' and *stud* 'pillar' count 1. We expected monosyllabic roots to be more likely than disyllabic ones to add an extra syllable, because trochees (*sw*) are more preferred than both dactyls (*sww*) and monosyllabic feet (*s*) (cf. Dresher and Lahiri 1991: 251). Syllabic weight (*rw*) was attributed to word

roots on the basis of the rhyme analysis shown in Table 3 above. We expected syllable number and syllabic weight to work in the same direction and to enhance each other’s effects: a higher number of syllables and a greater syllabic weight both decrease the probability of a word to acquire an extra syllable in the form of a new inflectional ending. Therefore, we created an additional interaction variable by multiplying (syll) and (rw). Table 4 shows the scores for the newly created variable ‘syll x rw’.

Table 4: Measuring word weight in an interaction variable of syllable structure and root weight.

Example (Rhyme structure)	syll	rw	score (syll x rw)
brōþer (VV + VC), dohter (VC + VC)	2	3	6
fæder (V + VC)	2	2	4
gōs (VVC), burg (VCC), cū (VV)	1	2	2
stud, hnit (VC)	1	1	1

4.1.2 Other independent variables

The remaining independent variables concern two aspects that turned out to be of relevance in other studies: frequency of occurrence (on various levels) and morpho-phonological salience of both the inherited and the analogical marker (e.g. Versloot and Adamczyk 2018; Hoekstra and Versloot 2019; Diessel 2007). By ‘absolute frequency’ (freq) we refer to the absolute number of occurrences in which a specific form represents a specific case-number category. If *brōþer* occurs 37 times as the ACC.PL of *brōþer*, then its absolute frequency in that function is 37. We interpret ‘absolute frequency’ as a measure of the entrenchment of a specific form in a specific category. In our model, we used the logarithm of the absolute frequency (relative scale), since it reflects the cognitive representation of quantities better than an absolute, linear scale (Dehaene 2003).¹⁰

Another independent variable in our model was the relative frequency of plurals as opposed to singulars (% PL). The singular/plural distinction has remained the most important functional contrast in English nouns. Plural

¹⁰ Note that most lemmas used in this study have a relatively high token frequency (out of 31 lemmas included in the study, 26 have a token frequency of 10 or more, and the average token frequency of all lemmas equals 380), which reduces the chance factor in the observed proportions.

forms (NOM/ACC.PL) are considered marked in comparison to the NOM.SG form, which counts as the default category (Lahiri and Dresher 1984: 159). This functional contrast conspires with a frequency difference: more frequent categories need less explicit marking, and less frequent categories tend to be (more explicitly) marked. We therefore included this aspect in two different ways: (1) as a functional-marking variable (SP) that applies to plural forms but not to singulars (assuming that plurals require explicit morphological marking for functional reasons), and (2) as the quantitative variable of the PL: SG proportion (% PL) (assuming that less frequent categories are more susceptible to analogical levelling and hence more likely to adopt the analogical endings *-as* and *-a* from the productive *a*- and *ō*-stems).¹¹

It needs to be pointed out that there is no golden standard for frequency distributions in language. Every situational context and every genre has its own specific frequency profile, and also historical corpora have their own genre-specific biases (cf. Versloot and Adamczyk 2014). Nevertheless, we used the figures derived from the *Dictionary of Old English* corpus, and regard them as approximations of the actual frequencies of use (by ‘average’ speakers of Old English). This assumption is based on the findings from various (synchronic) studies, which reveal strong correlations between corpora of written and spoken language (e.g. Brown 1984) or between corpus frequencies and acceptability judgements (expressing a subjective concept of ‘commonness’) (e.g. Bermel and Knittl 2012).

Two types of morpho-phonological salience (sal) were relevant in our study: (a) the salience of the marker in inherited forms, and (b) the salience of the inflectional endings that were analogically transferred from the productive classes. The two types of salience were encoded independently in the statistical test. As all inherited forms in this study were endingless, the only salient way in which they could signal case-number distinctions was by the presence or absence of *i*-mutation in the root vowel (e.g. NOM.SG *fōt* vs. DAT.SG *fēt* or *fāet* ‘foot’). Based on findings from earlier studies, we expected explicitly marked forms to be less likely to adopt new, analogical endings (cf. Section 3.2).¹² The innovative inflectional markers, on the other hand, were more heterogeneous with regard to salience. We already observed that in analogical innovations in the GEN.SG of the *r*-stems, the more salient masculine suffix *-es* was taken over

¹¹ The GEN and DAT.PL forms were not included as they were not endingless and, moreover, overlapped with the forms from the productive paradigms.

¹² It must be observed, at the same time, that even forms which do not have high salience can potentially develop into a productive pattern provided that their type frequency is high (cf. the endingless NOM.SG form of masculine *a*-stems).

more frequently than the less salient feminine suffix *-e* (see Section 3.1, Table 2). Our expectation was thus that salient markers should generally be taken over more often than less salient ones. The salience scale presented in Section 3.2.2 allowed us to distinguish three levels of salience of inflectional suffixes.

Lowest salience: Ø = no (additional) ending

Intermediate salience: *-e*, *-a*, *-u* = vocalic ending, e.g. *ō*-stem ACC.SG *gief-e* ‘gift’ vs. *r*-stem *mōder* ‘mother’

Highest salience: *-es*, *-as* = VC-ending, e.g. *a*-stem GEN.SG *dæg-es* ‘day’ and NOM/ACC.PL *dag-as* vs. *fæder* ‘father’s, fathers’.

4.2 Results and discussion

Of the eight variables whose influence we determined statistically, three turned out to show no significant impact, namely the (functional) singular/plural contrast, the number of syllables (syll), and root weight (rw). The latter two were overruled by the combined interaction variable ‘syll x rw’, which did turn out to be significant. Consequently, our model identified five statistically significant independent variables, of which three had a very strong effect, namely ‘sal’, ‘syll x rw’, and ‘i-mutation’. The other two, namely ‘freq’ and ‘% PL’ had a somewhat weaker effect. Table 5 presents the descriptives and the results of our logistic regression model.

The model predicts the distribution of nearly 90% of tokens in the dataset. Before interpreting the results of the model, a brief technical note on the scaling of the independent variables is in order. The variables ‘freq’, ‘% PL’, ‘i-mutation’ and ‘syll x rw’ are expected to correlate positively with the retention of archaic (endingless) forms: archaic forms that are highly frequent, plural forms that are more frequent than their corresponding singulars, forms with *i*-mutation, and ‘heavy’ forms are more resistant to the analogical adoption of new inflectional endings. For the variable *sal* (salience of the innovative ending), the opposite is true: the more salient an ending, the more likely it is to be analogically transferred. The different directions of the expected impact would produce both positive and negative coefficient values and Odds Ratios bigger or smaller than 1, which are difficult to compare. We therefore recalculated all variables in a way that they express the inclination towards innovation, and scaled them to a range between zero and one in order to make the Odds Ratios the expression of increased likelihood towards innovation between the minimal and maximal value of the independent variable. Thus, $\text{freq}[1-0]$ with Odds Ratio 7 means: the lower the frequency, the more likely the form is to adopt an analogical ending,

Table 5: Summary of the logistic regression model^a.

Model description				
The data set contains 11,776 relevant instances from 30 lemmas. 10,181 cases show Y = 0; 1595 cases have Y = 1, where ‘Y = 0’ are archaic forms and ‘Y = 1’ innovative forms with an analogical ending				
Overall Model Fit:				
Chi Square = 2896.9309; df = 5; p = 0.000				
Coefficients, Standard Errors, Odds Ratios				
Variable	Coeff.	StdErr	p	O.R.
sal[0–1]	4.39	0.14	0.000	81
syl x rw [1–0]	4.13	0.21	0.000	62
i-mutation[1–0]	3.10	0.12	0.000	22
%PL[1–0]	2.00	0.13	0.000	7
freq[1–0]	1.90	0.20	0.000	7
Intercept	–9.2130	0.2278	0.000	

^aThe abbreviations used in the presentation of the model refer to the following concepts: Y = dependent variable; *df* = degrees of freedom = number of independent variables; *Coeff.* expresses the arithmetic weight factor of the variables in the total model, presented along with the Standard Error (StdErr) and probability (p). The *Odds Ratio* (O.R.) expresses the power of a variable; in other words, it expresses the increase of likelihood in the dependent variable per single unit increment. It means that for every single unit increment in the independent variable, the chance for the presence or absence of a property in the dependent variable (the odds of being ‘yes’) increases by the value of the Odds Ratio. All variables are measured on a scale between 0 and 1.

and the least frequent items in the sample are seven times more likely to get an analogical ending than the most frequent ones.

Figure 2 shows the correlation between the statistically computed inclination of specific case-number forms of the 30 lemmas towards innovation (on the X-axis and scaled to a range between 0 and 1) and the actually observed proportions of innovative vs. archaic forms (also between 0 and 1 on the Y-axis). The inclination towards innovation is computed using the coefficient values for each of the variables from the statistical model. The figure shows that innovation is clearly triggered above the inclination level 0.4, where the proportion of innovative forms begins to rise significantly for some case-number forms. Innovation is inevitable above the inclination level 0.8, where no form is immune to analogical innovation. The S-curve is fairly steep, which points towards a strong threshold-like impact of the combined independent variables.

Figure 2: Correlation between the statistically computed inclination of specific case-number forms towards innovation (based on the variables in the statistical model) (X-axis) and the actually observed level of innovation (Y-axis).

The evaluation of the controlling factors reveals that three of them are particularly relevant for the analogical developments in the paradigms of *r*-stems and root nouns: (1) the salience of the analogical marker, (2) phonological structure of lemmas and (3) the salience of the inherited marker, i.e. *i*-mutation of the root vowel. Factors 1 and 3 are two different expressions of salience: while the former facilitates the adoption of an analogical inflectional ending, the latter inhibits it. The effect of the most powerful factor, i.e. salience of the new analogical marker, is illustrated in Table 6, where the proportions of innovative forms of masculine

Table 6: The type of analogical inflectional markers and innovation levels in the GEN.SG and NOM/ACC.PL in masculine and feminine root nouns and *r*-stems.

INNOVATIVE GEN.SG		ROOT NOUNS (%)	R-STEMS (%)
masculine	-es	95%	23%
feminine	-e	82%	5%
INNOVATIVE NOM/ACC.PL			
masculine	-as	3%	73%
feminine	-a	8%	64%

and feminine nouns in the two investigated classes are juxtaposed. The former are marked by a more salient exponent, the latter by a less salient one.

In both classes, the levels of innovation mostly correlate with the salience of analogical inflectional markers. The masculine paradigms, where the analogical marker is more salient, turn out to be more susceptible to analogical pressure than the feminine paradigms, marked by less salient exponents according to the salience scale. An exception is the NOM/ACC.PL of root nouns, where the impact of the salience of inherited markers (i.e. *i*-mutated vowels) works in exactly the opposite direction, rendering the paradigms of root nouns more resistant to analogical pressures from productive inflections. Accordingly, the divergent innovation levels in the plural – remarkably low in the root nouns and much higher in the *r*-stems – are clearly due to the salience of the inherited inflectional marker. That *i*-mutation had a strong effect on its own becomes also evident if one compares the DAT.SG forms of the root nouns *meolc* ‘milk’ and *fōt* ‘foot’. The inherited DAT.SG *meolc* is not marked by *i*-mutation, and gets an analogical suffix in 95% of all attestations. The inherited DAT.SG of *fōt*, on the other hand, is mutated *fēt*, and only 14% of all attestations show innovative inflections. Importantly, the combined effect of *i*-mutation and high plural proportion, which additionally enhances the effect of salience in the root nouns, overrules the syllable structure effect, which on its own would predict higher levels of innovation in plurals of monosyllabic root nouns than in plurals of disyllabic *r*-stems.

The divergent innovation levels in the GEN.SG also correlate with differences between the phonological structures of the *r*-stems (disyllabic) and root nouns (monosyllabic). The disyllabic structure of the former inhibits the adoption of analogical inflections, which would transform highly preferred trochees into less preferred dactyls. In the GEN.SG of monosyllabic nouns, on the other hand, the attachment of the innovative inflections (-es, -e) results in a trochee, and is thus favoured. Therefore, disyllabic nouns are more reluctant to adopt new endings than monosyllabic nouns. By a similar rationale, the nouns that are both disyllabic and have a heavy first syllable (i.e. the type *dohter*, *mōdor*, *sweostor*) are most resistant to analogical pressure. In fact, they are never attested with the *ō*-stem suffix -e in the ACC.SG. By contrast, extremely light feminine root nouns such as *stud*, *hnut* adopt analogical endings in 87% of NOM.SG forms.

Further evidence for the significance of metrical structure comes from the distribution of *r*-stem forms. *Fæder* is the only noun in this class that contains two light syllables (LL), while all others contain a heavy first syllable (HL, e.g. *brōpor*). Our data indicate that *fæder*, despite its high token frequency, shows a very innovative paradigm: 97% of all NOM/ACC.PL forms and 25% of GEN.SG forms carry innovative suffixes. In comparison, in *brōpor* analogical inflections

are found in 61% of NOM/ACC.PL forms and in 14% of GEN.SG forms. This implies that sequences of three light syllables (LLL), as in *fæderas* (NOM/ACC.PL), are counted as metrically similar to HL sequences and therefore as more trochee-like than sequences of a single heavy syllable followed by two light ones (i.e. HLL as in *brōþoras*, NOM/ACC.PL) (cf. Dresher and Lahiri 1991). Being more trochee-like, LLL sequences are more preferred than HLL sequences, which might explain why the light first syllable in *fæder* encouraged the adoption of analogical suffixes.

Other factors that affected the attested levels of innovation in the paradigms were the proportion of plural vs. singular forms (%PL) and the absolute frequency of specific paradigm forms (freq). The proportion of plurals turned out to be more important than the number contrast (SP), which was statistically insignificant. That the impact of frequency was relatively low may be due to the fact that the token frequency of most lemmas in the two investigated declensional classes was overall high, and had thus little differentiating effect.

Significantly, the fact that the salience of an analogical marker emerges as the single most important factor reflects specific properties of our data set, in which all inherited forms were endingless. This means that the new analogical markers never had to compete with an inherited suffix variant, but always replaced a zero marker, which was the least salient of all inflectional markers.

5 Conclusion

Our study demonstrates that the reorganisation of nominal inflection as attested in the early English material requires a multi-causal explanation. Analogical developments in different classes and paradigm forms result from the interplay of several factors. Nevertheless, that interplay is as systematic as it is complex, and makes the implementation of analogical transfers in nominal paradigms largely predictable. The results are compatible, in principle, with Paul's (1886) view that change in inflectional paradigms involves sequences of phonologically induced *disintegration* followed by analogical *reorganisation*. They also support the more generally accepted view that analogical developments react, or respond, to phonological changes. At the same time, our analysis demonstrates that the operation of analogical processes is continuously conditioned by a range of factors, which include phonological ones as well. Thus, phonology does not only trigger analogical changes, but it also controls the direction and the rate of the changes. The factors that our study revealed to be most strongly involved in directing the restructuring process are either purely phonological or have at least

a phonological component. The competition between zero-marking, which had resulted from phonological erosion, and analogical endings extended from the productive patterns was predominantly conditioned by the salience of inflectional markers, i.e. by their phonological shapes as measured on the salience scale. Also, the fact that paradigm forms with *i*-mutated root vowels were resistant to analogical suffixation represents the impact of a factor that crucially involves phonological substance.

Our study has also shown that analogical changes are not as irregular as Sturtevant's paradox suggests, but are in fact fairly predictable. They are conditioned by a range of factors that render the adoption of new analogical endings more or less likely, without making categorical predictions about individual tokens. Of course, it remains to be seen if the factors found relevant in the present study have a more general cross-linguistic relevance. Findings from other studies employing similar methodology (e.g. Hoekstra and Versloot 2019; Versloot and Adamczyk 2018) reveal that the values of the coefficients are fairly volatile and accordingly the odds ratios (rankings) cannot be directly generalised to other languages. At the same time, the same factors consistently emerge as statistically significant in various studies of other Germanic languages, and this suggests that they may indeed be cross-linguistically relevant, even though the weight of individual conditioning factors and the details of their mutual interactions will probably vary. Furthermore, complex dynamic systems such as languages are characterised by non-linear effects that cannot be entirely captured by the statistical methods applied in the present study.

Acknowledgements: We are very grateful to two anonymous reviewers as well as to the editors of the volume for their insightful remarks and comments, which helped to improve the quality of the paper. We would like to thank especially one of the anonymous reviewers for her/his suggestions on the revision of the section on phonological structure.

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