

‘Nominalization’ taken literally: A diachronic corpus study of German word-formation patterns

Stefan Hartmann

This paper presents a Cognitive-Linguistic and constructionist account of the diachronic development of two highly productive German word-formation patterns, namely *ung*-nominalization and Infinitival Nominalization. While *ung*-nominalization suffers a significant decrease in potential productivity and is subject to a growing set of constraints, no such restrictions seem to apply for Infinitival Nominalization. Thus, Infinitival Nominalization might supersede *ung*-nominalization as the default word-formation pattern for deriving nouns from verbs. It is argued that the diachronic developments are neatly accounted for in a usage-based theory of word-formation change. This account treats diachronic changes affecting word-formation patterns as constructional change, which is in turn conditioned by changes in the availability and prototypicality of construal options evoked by the respective constructions. This view is supported by an extensive empirical study based on corpus data from the 16th to the 19th centuries and by case studies of further developments throughout the 20th century.*

1. Introduction

The past few decades have seen a variety of studies dealing with German nominalization in the suffix *-ung* (e.g. *Bildung* ‘education’, *Warnung* ‘warning’) and, to a lesser extent, Infinitival Nominalization (e.g. *das Singen* ‘singing’, *das Denken* ‘thinking/thought’). Both patterns are highly productive in Present-Day German, and both have undergone significant diachronic changes. This paper aims at describing and accounting for these changes on an empirical basis. I will argue that the diachronic development of both patterns is best understood

* I wish to thank Michael Pleyer and two anonymous reviewers for helpful comments and suggestions. Thanks are also due to Damaris Nübling for suggesting and supporting this study as well as to Kristin Kopf for providing the Early New High German corpus data. All remaining errors are of course mine.

in a Cognitive-Linguistic and constructionist perspective. In this view, word-formation patterns can be seen as constructions, i.e. form/meaning pairings at various degrees of abstraction. These can be arranged on a continuum between atomic and specific units on the one hand and complex and schematic units on the other, the so-called lexicon-syntax continuum (cf. Croft 2001, Goldberg 2006, Hoffmann & Trousdale 2013). Morphological constructions can be formalized in terms of constructional schemas as proposed by Booij (2010). The word-formation patterns in question are represented by the schemas in (1) and (2).

(1) $[[x]_{Vj} \text{ ung}]_{Ni} \leftrightarrow [\text{CONCEPT with relation to SEM}]_i$

(2) $[[x]_{Vj}]_{Ni} \leftrightarrow [\text{ACTION}]_i$

The double arrow connects the form side of a construction with its meaning pole. As can be seen, the constructional schema contains an empty slot, represented by the variable x , in which verbs are inserted (indicated by subscript V). The resulting word-formation product is a noun, indicated by N . In Booij's account, which is rooted in Jackendoff's (e.g. 2010, 2013) Parallel Architecture framework, the lower-case variables i and j stand for lexical indices on the phonological (PHON), syntactic (SYN), and semantic (SEM) properties of words. The idea behind this is that each item in the lexicon can be assigned an arbitrary number. Since each word is considered "a pairing of three types of information" (Booij 2010: 5), namely PHON, SYN, and SEM, this index is attached to the three pieces of information. For example, if the verb *bake* carries the index 82, its properties can be referred to as PHON_{82} , SYN_{82} , and SEM_{82} . Consequently, "the relation between base word and derived word is expressed by co-indexation of the three pieces of information concerning the base word that recur in the derived word" (Booij 2010: 7). In the shorthand notation used in (1) and (2), PHON, SYN, and SEM are not listed separately, but condensed in the variables for the lexical indices.

However, the constructionist theory of word-formation and word-formation change presented in this paper differs from Booij's Construction Morphology (**CM**) in important ways. First of all, contrary to the modular approach of CM and the Parallel Architecture, morphology is not assumed to be an autonomous component of the grammar. Also, the notion of the (hierarchical) lexicon, which plays a key role in CM (cf. Booij 2010: 25-50), is abandoned in favor of the notion of the constructicon, which can be defined as a dynamic network of

interconnected units of linguistic information (cf. e.g. Diessel 2004: 13-40; Ziem & Lasch 2013: 95). Crucially, the information language users store about each construction is not limited to its form and to the conceptual content it evokes. Instead, language users also take note of the relative frequency of constructions, their pragmatic and discourse-functional properties, and their similarity to other constructions in terms of form and/or meaning (cf. Croft 2001, Taylor 2012).

The formalizations in (1) and (2) comprehensively capture the form side of each construction, whereas the meaning pole remains somewhat vague. This is due to the heterogeneity of concepts denoted by *ung*-nominals and, to a lesser extent, Infinitival Nominalizations. For example, *Landung* 'landing' denotes an event, *Heizung* 'heating installation' refers to an object, and *Bedienung*, lit. 'service', can be used in the sense of 'waiter/waitress'. In the case of Infinitival Nominalization, we find lexicalized cases such as *Schreiben* 'writing/letter' (from *schreiben* '(to) write'). Conceptual networks as proposed by Panther & Thornburg (2001) for English *-er*-nominals provide a helpful heuristic tool to capture such different meaning variants as well as their metaphorical and metonymic interconnections in more detail (see section 2.2 below).

The remainder of this paper is structured as follows. First I will give a brief overview of the diachronic development of *ung*-nominalization and Infinitival Nominalization (2). I will argue that the diachronic changes can be understood as constructional change (3), which is in turn determined by changes in construal (4). Then I will sum up the empirical findings and theoretical considerations and discuss their implications for a usage-based theory of word-formation (5).

2. ung-Nominalization and Infinitival Nominalization: Changes in morphological productivity and word-formation constraints

The diachronic development of *ung*-nominalization has been described as a change in morphological productivity by Demske (2000, 2002). If we adopt Scherer's (2006) definition of word-formation change as change in word-formation constraints, which is mirrored in morphological productivity, the diachronic change of *ung*-nominalization can thus be seen as a prime example of word-formation change. According to Demske (2000: 369), durative verbs (*glauben* 'believe'), inchoative verbs (*erblühen* 'blossom_{INCH}'), iterative verbs (*hüsteln* 'cough (slightly)'), and verbs of transfer (*geben* 'give') cannot function as base verbs of *ung*-nominals any more. According to Barz (1998:

65), Infinitival Nominalization comes in as a ‘replacement process’ to derive nouns from verbs for which *ung*-nominalization is blocked.

Although Demske’s study is corpus-based, she does not provide a detailed quantitative analysis of her data. Therefore, in the remainder of this section, I will first present the results of an analysis of Early New High German as well as New High German Corpus data with regard to changes in frequency and productivity (2.1). Then I will discuss the constraints affecting *ung*-nominalization in more detail (2.2) before I turn to the key notion of lexicalization and its pivotal role in the emergence of word-formation constraints (2.3).

2.1. Frequency and productivity

The notion of productivity in morphological analysis is notoriously multi-faceted and controversial. Bauer (1983: 62) calls it “one of the most contested areas in the study of word-formation”. However, in recent years, a consensus seems to have emerged that Baayen’s (e.g. 2009) measures of productivity provide a valuable basis for quantitatively assessing the productivity of word-formation patterns (cf. e.g. Scherer 2005, Hilpert 2013). Generally speaking, the concept of productivity refers to the likelihood of a morphological pattern to be extended to new cases (cf. Booij 2012: 70). Obviously, measuring the raw token frequency is insufficient to determine morphological productivity, although token frequency can be an indicator as to how often language users encounter word-formation products that are coined according to a specific pattern. Baayen (2009: 902) distinguishes between realized productivity, i.e. the type frequency of a construction in a given corpus, expanding productivity, i.e. the sum of hapax legomena (words occurring only once in the corpus) belonging to the construction in question in relation to the sum total of hapaxes in the corpus, and potential productivity, i.e. the sum of hapaxes belonging to a specific construction divided by the construction’s token frequency (cf. also Hilpert 2013: 132). We will be mainly interested in the potential productivity of word-formation patterns (labelled “morphological productivity in the narrow sense” in Baayen’s earlier work, e.g. Baayen 1992, cf. also Scherer 2006), as it arguably measures the relation of nonce-formations to established derivatives (and, hence, the potential of a word-formation pattern to coin new words) most comprehensively.

The data for our corpus study are derived from two sources:

a) The Mainz Early New High German Corpus (MzENHG), an as yet unpublished corpus compiled by Kristin Kopf and her colleagues at the University of Mainz. In the preliminary version used for the purposes of this study, the corpus comprises 82 texts (388,598 tokens,

49,525 types) spanning the time period from 1500 to 1710. The corpus is largely based on PDF scans from a project on German noun capitalization (Bergmann & Nerius 1998). Although the version exploited for this study differs slightly from the final version, even the preliminary corpus can be considered fairly balanced with regard to different dialects and text types (roughly divided into *Sachtexte*, comprising biological, medical, and legal texts, on the one hand and clerical texts on the other). In the version used here, the clerical subcorpus consists of 39 documents, while the *Sachtexte* subcorpus comprises 43 documents.

b) The GerManC Corpus (Durrell *et al.* 2007), a historical corpus of written German for the years 1650 to 1800. This corpus captures the early stages of the New High German period, which, according to the well-established periodization model going back to Scherer (1890), begins in the middle of the 17th century (cf. Roelcke 1998). GerManC contains 337 texts (683,302 tokens, 69,039 types). Unfortunately, the GerManC Corpus is only balanced for 50-year periods (as opposed to 30-year periods in the case of the MzENHG corpus). Since the changes affecting *ung*-nominalization and Infinitival Nominalization seem to apply across dialects and text types and since this corpus is much larger than the MzENHG corpus, a more fine-grained diachronic analysis can prove insightful nevertheless. In addition, an explorative analysis of the potential productivity of *ung*-nominalization in each text type reveals no significant differences between text types. Thus, for the purpose of the following analyses, the GerManC Corpus was divided into 10-year periods, whereas the 30-year periodization of the MzENHG Corpus was retained. To be sure, the two corpora are only comparable to a limited extent, which is why the right-hand side of the two-panel plots below (Figures 1-3) should not be misunderstood as a direct continuation of the respective left-hand panels. However, a cautious and tentative comparison seems legitimate. To be sure, the corpus size does have ramifications on the number of types and hapax legomena, which in turn influences the measures of productivity to be discussed below. Bauer (2001: 150) mentions the extreme example of the suffix *-iana* occurring only once in the Wellington Corpus of Written New Zealand English (in *Victoriana*). If we just apply the mathematical formula for potential productivity, dividing the number of hapaxes belonging to a specific morphological construction by the number of tokens belonging to the same construction, we get $P = 1/1 = 1$. Of course, the conclusion that *-iana* is entirely productive is unwarranted since the sample is much too small. The attestation of German *ung*-nominals and Nominalized Infinitives is far from this extreme situation. Baayen (1993: 187) points out that even rather small corpora can yield fairly

reliable evaluations of morphological productivity. As all measures of frequency and productivity rely on relative frequencies rather than absolute numbers, it is to be expected that the results obtained from two even-sized corpora would differ only slightly from those reported on below.

Both corpora were searched with AntConc (Anthony 2011) for relevant word forms.¹ The results were manually inspected to eliminate all false hits. In the MzENHG Corpus, 3705 *ung*-nominals (tokens; 810 types) and 1039 Nominalized Infinitives (NIs, tokens; 233 types) were retrieved. In the GerManC, 7040 *ung*-nominals (tokens; 1196 types) as well as 2188 NIs (tokens; 421 types) could be found. All analyses reported on below were performed with R (R Core Team 2013). For the significance tests, Kendall's Tau was used, which Hilpert & Gries (2009) have convincingly advocated as an appropriate measure of significance for assessing frequency changes in diachronic data.

Since types and hapax legomena play a crucial role in all measures of productivity, the question how these concepts are operationalized in the present study merits some discussion. As Plag (1999: 28f.) points out, the question arises if a word-formation product can be ascribed to a specific word-formation pattern if it is subject to further word-formation processes. His example is multiple affixation, e.g. *conventionalizable*. Since *-ung* is a so-called closing suffix, multiple suffixation does not pose a problem here as forms with multiple affixes such as *Ver-unrein-ig-ung* 'pollution' (lit. 'impure-ing') can unequivocally be identified as instantiations of *ung*-nominalization. However, both *ung*-nominals and – albeit to a lesser extent – Nominalized Infinitives can be used as constituents in a compound. Those cases in which they are used as first constituents in a compound were not considered in the present analysis, i.e. compounds like *Zeitungs-papier* 'newspaper-paper / paper on which a newspaper is printed' or *Lebens-alter* 'age, lit. life age' were not taken into account for methodological reasons: while it would have been possible to retrieve all *ung*-nominals used as first constituents in a compound automatically, detecting all compounds with a Nominalized Infinitive as first constituent would have required to manually scan all tokens containing the letter strings searched for (e.g. <en>, see endnote 2), not only those ending in these letters. At present, these compounds (for which it seems reasonable to predict a diachronic increase in both token and type frequency) must be left to future research.

By contrast, nominals functioning as last constituents in a compound were considered in the corpus analysis. Of course, these compounds pose a problem with regard to what has been labelled "bracket-

ing paradoxes" (Spencer 1988): Should a compound like *genehmhaltung* (roughly 'favor-keeping', meaning that you make sure to stay in someone's good favor) be analyzed as *[[genehm][haltung]]* or as *[[genehmhalt]ung]*? This has important ramifications for the annotation of the corpus and, consequently, for the measures of productivity reported below. If we choose the first option, we have to lemmatize *genehmhaltung* as an instance of *haltung* 'keeping'. If the latter analysis is chosen, by contrast, *genehmhaltung* has to be lemmatized as a type of its own. In a usage-based perspective, which conceptualizes language as a highly redundant inventory of form-meaning pairings (see section 2.3 below), these options do not necessarily exclude each other. Instead, we can assume a continuum between cases like *Buchhandlung* 'book shop', in which the compound analysis is evidently correct, on the one hand and cases like *Zurücklassung* 'leaving behind' that clearly suggest an analysis as a derivative with a complex base on the other. In the first example, the head constituent *Handlung* 'shop' is highly lexicalized and semantically disentangled from its base verb *handeln* '(to) act, (to) trade'. Consequently, there is no such verb as **buchhandeln* '(to) sell books'. In contrast to *Handlung*, **Lassung* is not attested independently, but only in compound structures or prefix constructions such as *Zurücklassung*, *Zulassung* 'permission', *Auslassung* 'omission', or *Einlassung* 'statement, testimony'. In all these cases, the corresponding complex verbs (*zurücklassen*, *zulassen*, etc.) do exist. In a case like *genehmhaltung*, both analyses could indeed be correct, i.e. the derivative could evoke associations both to the adjective *genehm* and the nominal *haltung*² as well as to the compound verb *genehmhalten*. But in lemmatizing the attestations of *ung*-nominals, the decision is of course binary. Therefore, all but the clear-cut 'compound' cases (such as *[[Buch]handlung]*) were treated as types of their own. Thus, *Buchhandlung* was lemmatized as *Handlung* 'shop', whereas *genehmhaltung* was lemmatized as a type of its own (despite the existence of an independent derivative *haltung*), as was *Zurücklassung* (which is a clear-cut case because **Lassung* does not exist).³

However, given the fact that such compound constructions are not as frequent in our diachronic corpora as they are in Present-Day German, these decisions can be assumed to have but a minor impact on the results.

2.1.1. Token Frequency

While token frequency is not a productivity measure in and of itself (cf. Hilpert 2013: 128), the token frequency of a construction can be considered a highly important factor for speakers' linguistic knowl-

edge of a construction. As Barðdal (2008: 95) points out, type frequency can be seen as “an indicator of the highest level of schematicity each construction exists at”, whereas token frequency “will be an important psycholinguistic factor singling out model items for speakers when they extend low-level constructions” (emphasis added). For example, the frequently cited suffix(oid) *-gate* was reanalyzed from the proper name *Watergate*. At the outset, *Watergate* thus only existed as a low-level construction, i.e. a highly specific, non-schematic construction with a type frequency of 1, but a very high token frequency. In Barðdal’s (2008: 34) terms, it exhibits a high degree of semantic coherence, which is an important prerequisite for a construction to be extended by analogy. This is exactly what happens in the case of the [X-*gate*] construction. The high token frequency of *Watergate* was important for the first new coinages in *-gate* to be understood, i.e. to prove communicatively successful. With the increase in token frequency, the construction becomes more general and more schematic, and its semantic coherence decreases to accommodate very different kinds of scandals (cf. Hartmann *to appear*). To be sure, the emergence of the [X-*gate*] construction, being a case of reanalysis, is a very specific case. Nevertheless, it provides a good model of what can reasonably be assumed to happen in the acquisition of any linguistic construction: at first, we only encounter low-level constructions (in the case of nominalization, word-formation products). The more schematic higher-level constructions (word-formation patterns) are then abstracted away from these more specific instances. Token frequency can be assumed to play a pivotal role in this process of generalization and abstraction. In Cognitive Grammar terms, both type and token frequency determine the salience of a specific constructional schema (cf. Taylor 2002: 291).⁴

Given the ubiquity of *ung*-nominals in Present-Day German⁵ and Demske’s observations concerning the morphological productivity of the word-formation pattern, we can predict an increase in token frequency as well as in realized and expanding productivity (see 2.1.2 and 2.1.3, respectively), while we expect a decrease in potential productivity (see 2.1.4). For Nominalized Infinitives, by contrast, we predict an increase in potential productivity as well as an increase in both type and token frequency, since it has to ‘replace’ *ung*-nominalization.

Over the Early New High German (ENHG) period, the token frequency of *ung*-nominals increases slightly, but not significantly. The overall frequency of Nominalized Infinitives is much lower, but its increase over the course of the ENHG period is significant ($\tau=0.57$, $T=22$, $p_{\text{one-tailed}}<0.05$). Over the New High German (NHG) period covered

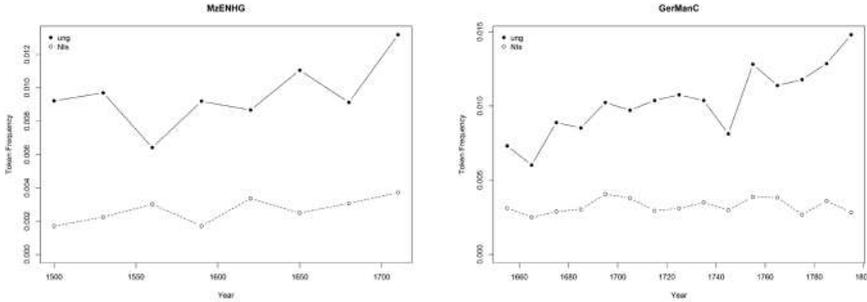


Fig. 1. Token frequency of *ung*-nominalization and Infinitival Nominalization in the MzENHG Corpus and in the GerManC Corpus, respectively.

by the GerManC, *ung*-nominalization experiences a highly significant increase in token frequency ($\tau=0.73$, $T=91$, $p_{\text{one-tailed}}<0.01$), which is consistent with our predictions. With regard to Infinitival Nominalization, by contrast, no significant changes can be detected during this period.

2.1.2. Realized Productivity

Regarding realized productivity, we find a significant increase for both *ung*-nominalization and Infinitival Nominalization in the ENHG period. The overall more frequent pattern, *ung*-nominalization, becomes even more type-frequent ($\tau=0.57$, $T=22$, $p_{\text{one-tailed}}<0.05$), which indicates that the word-formation pattern yields new coinages, while existing derivatives are retained. In the case of Infinitival Nominalization, the increase is even highly significant ($\tau=0.71$, $T=24$, $p_{\text{one-tailed}}<0.01$). Over the period covered by the GerManC Corpus, the type frequency of *ung*-nominalization continues to increase ($\tau=0.35$, $T=71$, $p_{\text{one-tailed}}<0.05$), whereas no significant changes can be detected for Infinitival Nominalization.

2.1.3. Potential Productivity

The measure of potential productivity is probably the most interesting one in assessing the potential of a word-formation pattern to be extended to new cases. To be sure, not all hapax legomena are neologisms, especially in rather small historical corpora (cf. Cowie & Dalton-Puffer 2000: 432). However, the number of hapax legomena is assumed to correlate with the number of new coinages (cf. Baayen 1993: 189). Given Demske's hypothesis that the diachronic change of *ung*-nominalization can be interpreted as a

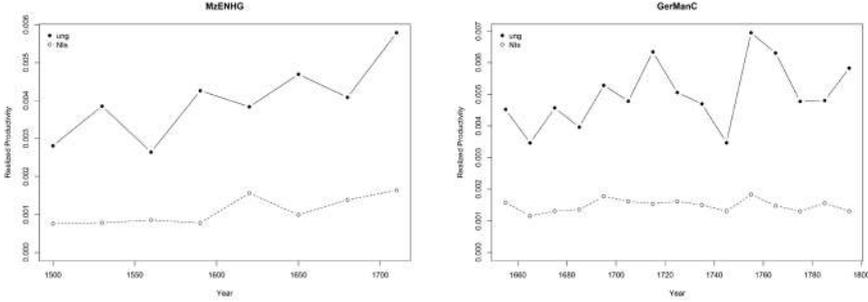


Fig. 2. Realized Productivity of *ung*-nominalization and Infinitival Nominalization in the MzENHG Corpus and in the GerManC Corpus, respectively.

change in morphological productivity due to an increasing number of constraints affecting this word-formation pattern, we predict that its potential productivity decreases over time. If Infinitival Nominalization is indeed used as a ‘replacement’, we should expect its potential productivity to rise significantly.

The data from the MzENHG Corpus do not verify our hypotheses. On the contrary, the potential productivity of *ung*-nominalization even increases slightly, though not significantly. By contrast, in the GerManC period, the potential productivity of *ung*-nominalization suffers a highly significant decrease ($\tau=-0.61$, $T=20$, $p_{\text{one-tailed}} < 0.01$), whereas the potential productivity of Infinitival Nominalization increases significantly ($\tau=0.33$, $T=70$, $p_{\text{one-tailed}} < 0.05$). The crucial changes, then, seem to take place at the beginning of the New High German period.

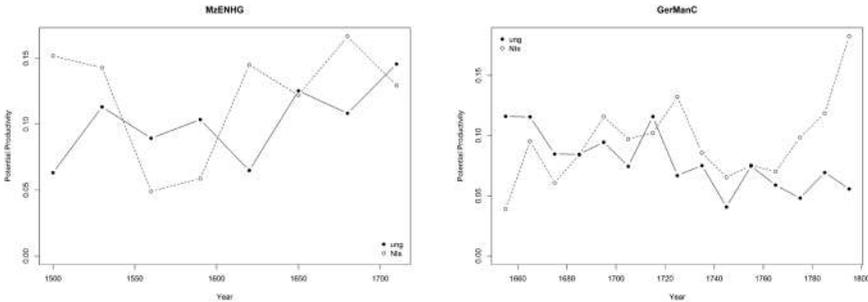


Fig. 3. Potential Productivity of *ung*-nominalization and Infinitival Nominalization in the MzENHG Corpus and in the GerManC Corpus, respectively.

2.2. In search of the impossible: Tracking the constraints

The constraints affecting *ung*-nominalization have been extensively discussed from different theoretical perspectives. Demske (2000) argues that these constraints are entirely semantic in nature. Morphological restrictions have been postulated: for example, Paul ([1920] 1968: 74) holds that transitive verbs and morphologically complex verbs lend themselves more easily to *ung*-nominalization. According to Demske (2000: 369), however, the prevalence of transitive bases can be explained by the fact that there are more transitive verbs in German than intransitive ones, while the apparent morphological restriction can be accounted for in semantic terms: for example, the simplex verb *arbeiten* '(to) work' is durative and therefore ruled out by the semantic constraints she assumes (see section 2 above); *bearbeiten* '(to) process/handle', by contrast, is perfective and thus eligible for *ung*-nominalization.

However, Knobloch (2002) mentions some counterexamples to Demske's semantic constraints. For example, *Erblindung* 'becoming blind' is entirely grammatical (cf. Shin 2001), which runs counter to Demske's assumption that inchoative verbs cannot be nominalized with *-ung*. Shin (2001) accounts for the fact that *Erblindung* is considered grammatical, while *Erblühung* 'blossoming' and *Verschließung* 'locking' are not,⁶ in terms of event structure, postulating two conditions that determine if a verb can undergo *ung*-nominalization: first, the verb's event structure must include a source state, a target state, and a transition with a terminating point between source and target state (necessary condition, e.g. not blind → CHANGE → blind). In addition, the theme argument must undergo a change of properties, and it must acquire an identical and constant target-state property (sufficient condition). However, actual language use provides some counterexamples. *Verschließung* is not only attested as a legal term (§ 34 Beurkundungsgesetz – locking / deposit of documents), but also in a fairly transparent variant. Although, admittedly, most attestations in the German Reference Corpus (Deutsches Referenzkorpus, DeReKo) do meet Shin's sufficient condition since they refer to the permanent closure of, say, a mine, an oil field or a nuclear disposal site as in (3), this does not hold for all instances of *Verschließung*, as (4) shows.

- (3) *Die bergbaulichen Maßnahmen seien keine Vorkehrungen zur geplanten Stilllegung und endgültigen **Verschließung** des Endlagers.*

'The measures in terms of mining are_{CONJ} no preparation for the quiescence and final closure of the disposal site'

(BRZ06/DEZ.06910 | COSMAS II)

- (4) *Um dieses [...] Problem zu lösen, ermöglicht die Motorweiterlaufschaltung [...] die gleichzeitige **Verschließung** des Fahrzeugs von außen.*

‘To solve this problem, the engine run lock allows for the simultaneous locking of the vehicle from outside’

(WPD11/M16.47732 | COSMAS II)

Roßdeutscher (2010) and Roßdeutscher & Kamp (2010), combining the frameworks of Distributed Morphology and Discourse Representation Theory, propose an account fairly similar to Shin’s. According to them, only ‘bi-eventive’ verbs can be nominalized with *-ung*, i.e. verbs with an event structure consisting of (i) a state and (ii) an event that causes it. For example, *Säuberung*, from *säubern* ‘(to) clean’, is possible since its base verb has a property-denoting root, $\sqrt{\text{sauber}}$ ‘clean’. **Wischung* ‘wiping’, by contrast, is ungrammatical since its base verb has a manner-denoting root, namely $\sqrt{\text{wisch}}$ ‘wipe’. However, this only works out straightforwardly for *ung*-nominals derived from de-adjectival verbs such as *erblinden* and *säubern*; *ung*-nominals denoting a state of mind such as *Aufregung* ‘excitement’ pose a problem to this account. The same is true for *ung*-nominals from verbs such as (*sich*) *bewegen* ‘(to) move’, whose meaning can be construed as a cyclic activity in the sense of Croft (2012), i.e. as dynamic and without an inherent end point or result state.

While these examples show that Demske’s restrictions do not apply without exception, her semantic constraints can be held up as general tendencies. This fits in with the usage-based approach advocated in this paper, which argues for a schema-based account rather than assuming exceptionless rules. In this view, the meaning of a (polysemous) construction can be conceptualized as a semantic network with (more) prototypical and (more) peripheral members. The ‘nodes’ in this network are connected via metaphorical and metonymic meaning chains. Fig. 4, loosely based on Panther & Thornburg’s (2001) conceptual network for *er*-nominals, illustrates how a semantic network for *ung*-nominals in Present-Day German might look like. The most prototypical meaning variants are shaded in grey. The notion of ‘bounded region’ will be explained in further detail in section 4.

Of course, the linguistic knowledge language users have about a construction goes beyond the semantic aspects captured in Figure 4. For example, it seems plausible that in Middle High German, *hoffenunge* ‘hope’ (from *hoffen*) prevailed over the regularly formed *hoffunge* because it conforms to the syllable structure of most Middle High German *ung*-nominals (cf. Hartmann 2013). The irregular /n/ is

still retained in Present-Day German *Hoffnung*.

To sum up, in the constructionist account proposed here, word-formation constraints are not conceived of as (exceptionless) rules. Instead, they are considered to emerge from actual language use. Language users form abstractions and generalizations over the instances of a specific pattern they encounter, and each usage

event may influence or reconfigure the conceptual network associated with a specific construction (cf. Goldberg 2006, Bybee 2010, Taylor 2012). In other words, language users form a constructional schema by abstracting over constructs, i.e. actual instances of use (cf. Traugott & Trousdale 2013: 2). Future constructs are deemed felicitous if they are sanctioned by the constructional schema (or, in some cases, if they display substantial analogies to existing word-formation products). Of course, this is a matter of degree as well: while a derivative such as *Landung* 'landing' might be judged a prototypical *ung*-nominal since it adheres to almost all or at least to the most important aspects of the constructional schema, *Verschließung* 'locking' can be considered a peripheral case due to its semantic deviation from the default pattern.

2.3. Lexicalization

Demske (2000) has emphasized the pivotal role of lexicalization in the diachronic development of *ung*-nominalization. For example, *Heizung* 'heating installation' cannot denote the *'process of heating' any more, and *Lesung* (from *lesen* '(to) read') does not refer to the *'process of reading' in Present-Day German, but rather to a reading event or the reading of a draft law. *Bedienung* (from *bedienen* '(to) attend/serve'), by contrast, can still be used in the fairly processual sense of 'service', but can also refer to a person, namely a waiter or waitress. Scherer (2006: 12) points out that in a process of reanalysis, these meaning variants (e.g. OBJECT, PERSON) are abstracted away from the lexicalized word-formation products and transferred to the word-formation pattern itself. Hence, the object and person readings are not confined to single lexicalized derivatives anymore but carried over to other *ung*-nominals.

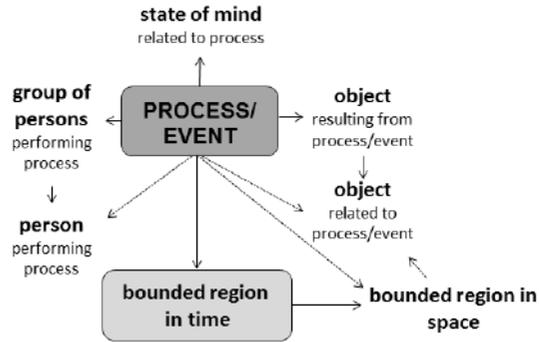


Fig. 4. A conceptual network for *ung*-nominalization in Present-Day German.

Before we take a look at specific examples of lexicalization in the domains of *ung*-nominalization and Infinitival Nominalization, we have to discuss the role of this process in a radically constructionist approach as outlined in the Introduction. Brinton & Traugott (2005: 96) define lexicalization as:

the change whereby in certain linguistic contexts speakers use a syntactic construction or word formation as a new contentful form with formal and semantic properties that are not completely derivable or predictable from the constituents of the construction or the word formation pattern.

Lexicalization, in Brinton & Traugott's (2005: 145) view, is a gradual process, which is consistent with the conceptualization of the constructicon as a dynamic network of constructions. The gradual nature of lexicalization follows straightforwardly from the observation that non-compositionality is a matter of degree (cf. Fried 2013: 423). For example, the German simplex word *Welt* 'world' goes back to Old High German *weralt* 'age of man' (cf. Salmons 2012: 170). Due to semantic change and phonological reduction, its internal constituent structure is entirely opaque to modern language users. By contrast, the aforementioned *ung*-nominals are easily identifiable as instantiations of the constructional schema in (1), although their semantics might deviate from the default meaning of word-formation products in *-ung*. In a constructionist perspective, then, lexicalization can be interpreted as a shift on the syntax-lexicon continuum. This ties in neatly with the two functions of word-formation that have often been postulated in the morphological literature: 'labeling' of new concepts or lexical enrichment on the one hand and syntactic recategorization on the other (cf. Kastovsky 1986: 410; Dressler 1987: 99; Römer 1987: 220f.). As Kastovsky (1986: 412) points out, these two functions "mark the end points of a functional scale and are completely dissociated only in certain extreme cases".

To be sure, even the meaning of fully transparent derivatives is not entirely identical to the semantics of their respective bases. In Langacker's (1987b: 57) terms, "nominalization involves some type of conceptual 'reification'", that is, the conceptual content of the base is construed in a more 'nouny' fashion. Langacker's (1987a, 1991b) distinction between conceptual content and construal can be seen as roughly correlating with the two functional poles mentioned above (i.e. lexical enrichment and syntactic recategorization). The term 'conceptual content' refers to the 'objective' properties of the entity to which a linguistic unit refers (cf. Langacker 2008: 43). 'Construal', by contrast, refers to how that

content is shaped and construed (cf. Langacker 1991a: ix). The semantic import of word-class-changing processes such as *ung*-nominalization and Infinitival Nominalization can be characterized in terms of construal. While both nominalization patterns do not tend to considerably modify the conceptual content of their bases, they do impose a specific construal on that content (Figure 5). However, like all aspects of a construction's semantics, these construal patterns are subject to diachronic change. Also, like all aspects of a construction's semantics, they emerge through abstractions over actual language use. Therefore, the importance of lexicalized items can hardly be overestimated.

In the case of *Heizung* 'heating (installation)', the lexicalization process only took place throughout the 20th century, as a corpus search in the core corpus of the Digital German Dictionary (*Digitales Wörterbuch der Deutschen Sprache*, DWDS) shows. At the beginning of the 20th century, the processual reading was still prevalent, as the examples in (5) and (6) show.

- (5) *Für Unterhaltung, Bewachung, Beleuchtung, **Heizung**, Reinigung u.s.w. des neuen Domes und der Fürstengruft wurden in das betreffende Kapitel 15,000 Mark eingesetzt.*

'For maintaining, lighting, **heating**, cleaning etc. the new dome and the crypt, 15.000 Mark were invested in the cathedral chapter in question'
(Berliner Tageblatt 02.03.1904 | DWDS)

- (6) *... während die **Heizung** in den meisten Fällen noch durch die altehrwürdigen Kachelöfen erfolgt.*

'...while **heating**, in most cases, is still effected by means of the venerable tiled stoves'
(Vossische Zeitung, 03.03.1905 | DWDS)

At the end of the 20th century, by contrast, most attestations exhibited the object reading as exemplified in (7) and (8).

- (7) *Arne sitzt auf dem Stuhl vor meinem Schreibtisch oder auf der **Heizung**.*
'Arne is sitting on the chair in front of my desk or on the heating installation'

(Merian, *Der Tod des Märchenprinzen*, Hamburg 1980, p. 137 | DWDS)

- (8) *Er lachte und half den Kocher und die **Heizung** hochschleppen.*

'He laughed and helped to carry up the boiler and the **heating device**'
(Jentzsch, *Seit die Götter ratlos sind*, München 1999, p. 216 | DWDS)

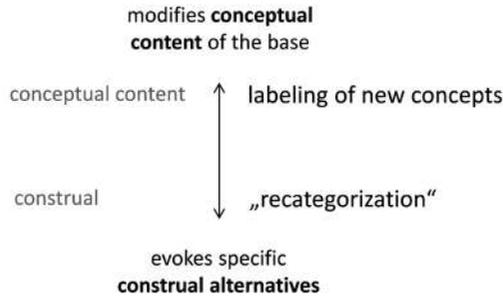


Fig. 5. Functions of word-formation in relation to the notions of ‘conceptual content’ and ‘construal’.

A quantitative analysis confirms the impression that the frequency of use of *Heizung* in the processual sense decreases drastically ($\tau=-0.82$, $T=4$, $p_{\text{one-tailed}}<0.01$), whereas the amount of attestations exhibiting an object reading increases very significantly ($\tau=0.69$, $T=38$, $p_{\text{one-tailed}}<0.01$).⁸

Another case in point is *Lesung* from *lesen* ‘(to) read’, which originally referred to the process of reading, but also to the reading of a draft bill. In the 20th century, the additional meaning ‘reading event’ emerged and quickly caught up with the juridical reading, while the processual reading came out of use (cf. Hartmann 2014). Both examples, *Heizung* and *Lesung*, show that lexicalization can be understood as “the move to a more contentful construction” (Trousdale 2008: 171). From the above considerations, the question arises whether lexicalized derivatives such as *Heizung* and *Lesung* should be considered independent constructions at the word level or instantiations of the morphological constructional schema in (1). However, the usage-based conceptualization of language as a “massive, highly redundant inventory of conventional units” (Langacker 1988: 133) suggests that they might be both. Unfortunately, psycholinguistic research on *ung*-nominalization has not yet considered this possibility. Insightful though they are, the studies by Harald Clahsen and his colleagues (e.g. Clahsen *et al.* 2003, Clahsen & Neubauer 2010) have implicitly fallen prey to what Langacker (1987: 29) calls the “rule/list fallacy”, i.e. the assumption that linguistic units necessarily must be either rule-derived or listed, *tertium non datur*. Consequently, they do not take the gradualness of lexicalization into account, which is why they partly use stimuli that have to be considered problematic. For example,

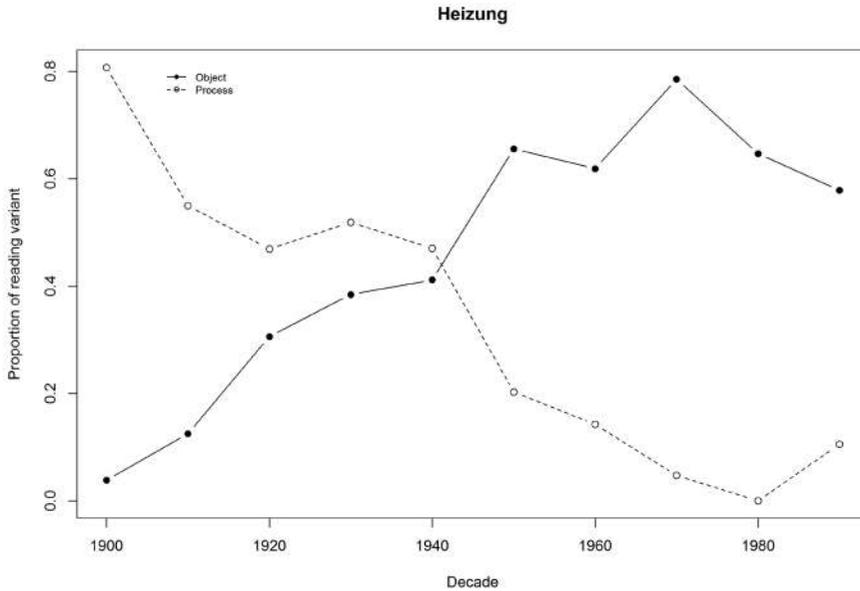


Fig. 6. The lexicalization of *Heizung* as attested by data from the Digital German Dictionary.

the fact that *Zündung* (used as a stimulus in Clahsen & Neubauer 2010) almost certainly evokes an entirely different semantic frame than its base verb *zünden* '(to) ignite', since it prototypically refers to an engine's ignition system, is not taken into account. To be sure, uses of *Zündung* in a fairly transparent reading are attested and even relatively frequent. Nevertheless, this word-formation product, like many others, has to be considered partly lexicalized.

3. Constructional change

Word-formation change as characterized throughout this paper can be seen as an instance of constructional change in Hilpert's (2013) sense. According to Hilpert (2013: 16),

[c]onstructional change selectively seizes a conventionalized form-meaning pair of a language, altering it in terms of its form, its function, any aspect of its frequency, its distribution in the linguistic community, or any combination of these.

Importantly, the notion of constructional change is not co-extensive with language change. While language change often operates across constructions – for example, in the case of phonological changes such as Grimm’s law –, constructional change pertains to the specific construction in question. In the case of word-formation change, the word-formation pattern, i.e. the constructional schema, is altered. Note that Scherer’s (2006) definition of word-formation change as change in word-formation constraints is highly compatible with Hilpert’s concept of constructional change since she scrupulously distinguishes between changes at different levels of linguistic description: according to Scherer (2006), only changes affecting the word-formation patterns (i.e. constructions) can be seen as instances of word-formation change proper (or “word-formation change in the narrow sense”), whereas developments affecting word-formation products (e.g. lexicalization) or the system of word-formation (e.g. the inventory of word-formation patterns available) can be considered interface phenomena at best.

However, as Hilpert (2011: 69) makes clear, constructional change does not happen in a vacuum. Instead, the change of one construction may have repercussions on other constructions connected to it. We can assume that different constructional changes conspire in the diachronic change of *ung*-nominalization and Infinitival Nominalization as well. I will argue that these constructional changes are tightly interwoven and tied to changes in construal, which will be the topic of the next section.

The most obvious change affecting *ung*-nominalization pertains to the constructional schema itself. For Early New High German (ENHG), we can posit the constructional schema (9), which is superseded by (1), repeated here as (10):

(9) $[[x]_{V_j} \text{ ung}]_{N_i} \leftrightarrow [\text{ACTION}_{j_i}]_i$

(10) $[[x]_{V_j} \text{ ung}]_{N_i} \leftrightarrow [\text{CONCEPT with relation to SEM}_{j_i}]_i$

In ENHG, *ung*-nominals usually refer to the process denoted by the base verb, as do Nominalized Infinitives in Present-Day German. In New High German, the range of available concepts grows larger. As pointed out above, this change can at least partly be explained by lexicalization of frequent word-formation products and subsequent reanalysis. In Booij’s (2010) terms, various constructional subschemas emerge. Booij’s concept of constructional subschemas basically trans-

fers Panther & Thornburg's (2001) conceptual network approach, introduced in section 2.2 above, to a constructionist framework: "[W]e need a 'regular polysemy' approach in which a prototypical meaning forms the starting point for deriving other meanings through the semantic extension mechanisms of metaphor and metonymy" (Booij 2010: 78). Constructional subschemas, which often exhibit their own idiosyncrasies (cf. Hilpert 2013: 65), can be roughly paralleled with Traugott's (2008: 236) notion of 'meso-constructions', i.e. "sets of similarly-behaving specific constructions".

Each case of lexicalization can be seen as constructional change at the word level. The subsequent reanalysis, which entails the emergence of new word-formation meanings, follows a pattern that is well-attested in different languages. As Panagl (1987: 146) puts it,

nouns of action generally show an inherent tendency toward categorical change of meaning. This development, for which the term 'drift', going back to Edward Sapir, seems convenient, tends to proceed through the level of resultative noun (*nomen acti*) and in many cases reaches the level of concrete noun (interpretable as instrumental or local), in certain cases achieving even an agentive reading.

Hence, the semantic change of specific word-formation products modifies the (schematic) meaning of the word-formation pattern. If we interpret word-formation patterns as tied to construal patterns, as outlined in section 2.3, constructional change at the word level can be seen as closely tied to construal changes, i.e. to modifications in the conceptual network of abstract meanings evoked by the morphological construction.

4. Construal changes

As discussed above (section 2.3), the notion of construal refers to the way a specific linguistic unit is 'shaped' in the process of conceptualization. Importantly, the 'construal operations' proposed in the Cognitive-Linguistic literature (e.g. Croft & Cruse 2004, Langacker 2008) are seen as instantiations of general cognitive abilities (cf. Pleyer 2012: 290). For example, Langacker (1996) draws direct parallels between grammatical viewpoint phenomena and visual perception. While most of the construal patterns listed by Croft & Cruse (2004: 46) are solely based on introspective judgments, the growing field of experimental semantics has begun to investigate them on empirical grounds (cf. Matlock & Winter *to appear*). As Bergen's

(2012) overview shows, much experimental research seems to confirm the psychological reality of the construal patterns posited in Cognitive Linguistics.

The diachronic development of *ung*-nominalization can be interpreted in terms of construal changes in a double sense. On the one hand, the construal operations of metaphor and metonymy underlie the processes of lexicalization discussed above. In the case of *Heizung*, one specific element that plays a prominent role in the ‘heating’ frame, namely the instrument used for this purpose, is metonymically referred to by means of the action noun. In the case of *Lesung*, the original, more general, meaning is narrowed to a specific kind of reading (reading out a text) and enriched with a frame that involves the (legal or cultural) setting in which the reading occurs. On the other hand, the inventory of construal options potentially evoked by the word-formation pattern grows larger. It is an open question whether we can posit one highly abstract schema encompassing the variety of meanings mentioned in the conceptual network in Fig. 4 or if the different constructional subschemas exist largely independently of each other. However, it seems safe to assume that language users do generalize to a certain extent over the different reading variants as they identify the different word-formation products as instantiations of the same pattern. In other words, we can assume that the emergence of a new micro-constructional or constructional subschema does not leave the construction itself unaffected. This might partly explain the constraints affecting *ung*-nominalization in Present-Day German. Demske (2000) has already observed that ENHG *ung*-nominals are much more ‘processual’ than their present-day counterparts. In fact, they even display certain similarities to the English progressive (cf. Demske 1999), which has been analyzed in terms of viewpoint by Langacker (2008), Verspoor (1996), and others. The progressive form evokes a conceptualization from an ‘internal’ viewpoint, i.e. “the position from which the situation is viewed is contained in the ongoing process itself (so that any boundaries are not ‘in view’)” (Verhagen 2007: 53). Recent psycholinguistic findings have lent support to this analysis (cf. Matlock 2001; Matlock *et al.* 2012). Many ENHG *ung*-nominals can also be interpreted as profiling the ongoing process from an involved viewpoint rather than its boundaries. Consider the examples in (11-13):

- (11) *der [...] nicht bald ein Nacht ohn vielfaltig auffstehen vnd **beschawung** des Gestirns zugebracht*

'who hardly spent one night without rising frequently and **watching** the stars'

(WOBD-1620-ST-078 | MzENHG)

- (12) *da hab ich meine Fastnaechte mit **Lesung** deß Ciceronen zugebracht*

'So I spent my Lent nights **reading** Cicero'

(HUMA_P1_WOD_1698_MythoscopiaRAW | MzENHG)

- (13) *daß sie stehe in der stiftung/ befelch vnd ordnung vnsers Herren Jesu Christi/ vnnnd nicht in der blossen **sprechung** der wort Christi/*

'that it [the consecration of the host] is [lit. stands] in the institution, command, and order of our Lord Jesus Christ, and not merely in **speaking** the words of Christ'

(WOBD-1560-KT-043 | MzENHG)

Note the coordination of a Nominalized Infinitive (underlined) and an *ung*-nominal in (11), which points to the similarity in meaning of both word-formation patterns in the ENHG period. Moreover, (11) exemplifies a syntactic construction in which ENHG *ung*-nominals and Nominalized Infinitives (NIs) frequently occur. In this construction, the word-formation product serves as the complement of a preposition (cf. Demske 2000). The nominal is used without a determiner, and the PP constitutes an independent, principally omissible constituent that can be paraphrased as a subordinate clause (as in (16)).

- (14) *Artikel 15: Waß Sie **bey Lernung** der Hex- und Zauberey vor worte gebraucht?*

'Article 15: Which words has she used **in learning** witchcraft and sorcery?'

(LEGA_P1_OMD_1659_HexenRAW.txt | GerManC)

- (15) *Es ist wahr; die Liebe gegen jemanden ist bisweilen kraefftiger; **in Lenckung** der Hertzen und **Bezwingung** gewisser Neigungen, als die Furcht.*

'It is true, love is sometimes stronger, in **steering** the heart and **overcoming** certain propensities, than fear.'

(HUMA_2_OMD_1729_Biedermann | GerManC)

- (16) *so wöllen wir jedoch/ das hinfüro/ so viel möglich/ ein Beysitzer/ [...] bey **haltung** der nachgericht Persönlich seyn solle/*

'But we want that henceforth, if at all possible, an assessor should be present personally when the re-negotiations are held (lit. at the **holding** of the re-negotiations)'

(NOBD-1620-ST-082.txt | MzENHG)

In Present-Day German, this construction is restricted to a number of idiomatic cases such as *unter Begutachtung* ‘under review’ or *nach Abwägung aller N* ‘after considering all N’. Figure 7 shows that the relative frequency of [PREP NOM] constructions with *ung*-nominals decreases significantly ($\tau=-0.71$, $T=15$, $p<0.01$). The development of the same construction with NIs, plotted in the right panel, is less straightforward. Perhaps boosted by the high frequency of *ung*-nominals as complements of prepositions, the frequency increases at first, but then decreases again. Due to the smaller number of overall attestations for NIs, the data show more outliers and are less reliable than those for *ung*-nominalization.

Figure 8 shows, for *ung*-nominalization, how the productive [PREP NOM] construction ‘freezes’ into a rather small inventory of idiomatic phrases. The two graphs plot the number of different types attested for this construction in absolute numbers and in relation to the total number of types in *-ung*, respectively. In other words, the plots show how many combinations of specific prepositions with specific *ung*-nominals are attested in each corpus period. The absolute numbers in the left panel of Fig. 8 already point to an overall decrease in the number of possible combinations. Due to the different sizes of the corpus periods, however, the absolute numbers are not significant in and of themselves. If we normalize them by relating them to the total number of types in *-ung* in each corpus period, plotted in the right panel of Fig. 9, the decrease in relative type frequency is highly significant ($\tau=-0.64$, $T=19$, $p_{\text{one-tailed}}<0.01$). The development is also significant if we track the type frequency of [PREP V-*ung*] attestations in relation to the corpus size, i.e. to the total number of tokens in each period ($\tau=-0.35$, $T=34$, $p_{\text{one-tailed}}<0.05$).

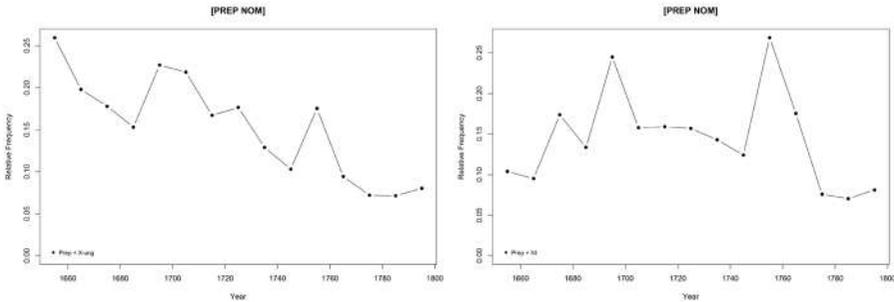


Fig. 7. *ung*-nominals and NIs as complements of prepositions in relation to the total number of attestations for the respective word-formation pattern.

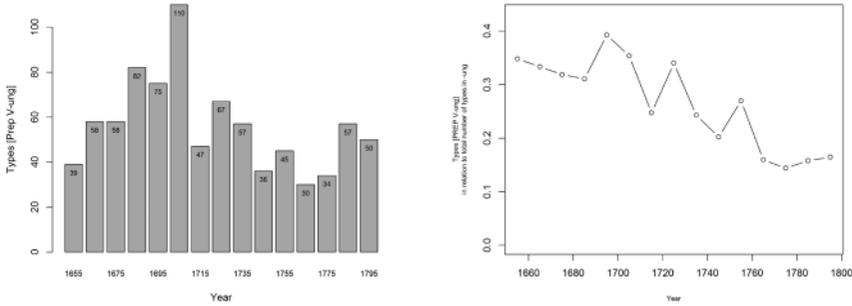


Fig. 8. Absolute and relative type frequency of [PREP V-ung] constructions.

Two more developments on the syntactic level point to the conclusion that the word-formation pattern of *ung*-nominalization assumes more ‘concrete’ construal patterns over time. First, the proportion of *ung*-nominals occurring with a determiner increases significantly ($\tau=0.6$, $T=84$, $p<0.01$). As Vogel (1996: 131) points out, determiners tend to ‘shift’ the meanings of nominalizations towards a ‘count noun’ reading – hence, the construal becomes more concrete and ‘nounier’. However, the increase in the use of determiners might also be a more general development since it can also be observed in the case of Infinitival Nominalization ($\tau=0.49$, $T=78$, $p<0.05$). What is more, the proportion of pluralized *ung*-nominals increases highly significantly ($\tau=0.77$, $T=93$, $p<0.01$). Pluralization almost necessarily entails a certain degree of concretization (cf. Vogel 1996: 115). Again, a ‘count noun’ construal is evoked, rendering the word-formation products more ‘nouny’. Langacker (1987a, b) defines count nouns as “a bounded region in some domain”. In the terminology of Cognitive Grammar, a domain is “any knowledge configuration which provides the context for a conceptualization” (Taylor 2002: 589). Time and space definitely belong to the most salient and most important domains. Thus, many of the emerging reading variants of *ung*-nominals can be subsumed under the broad notions ‘bounded region in time’ and ‘bounded region in space’, respectively. For example, *Veranstaltung* ‘event’, *Gerichtsverhandlung* ‘trial/court case’, and *Lesung* ‘reading event’ all refer to a bounded region in time, while *Ausstellung* ‘exhibition’ as well as one possible reading of *Ausgrabung* ‘excavation (site)’ refer to bounded regions in space. Considering the changes discussed in this section, the ‘bounded region’ readings of *ung*-nominalization can be said to gain in prototypicality. The

decrease of *ung*-nominals in [PREP NOM] constructions and the continuous rise of *ung*-nouns used with a determiner or in the pluralized form can be seen as an indicator of this development.

In the case of Infinitival Nominalization, by contrast, pluralization hardly ever occurs, which is still the case in Present-Day German (cf. Barz 1998). Indeed, the constraints on pluralization have even grown stronger, which is probably due to the very fact that pluralized forms are highly infrequent. While lexicalized NIs such as *das Schreiben* ‘the writing / letter’ can be pluralized if they refer to a concrete object (*die Schreiben*), this is not possible for abstract nouns. For example, *Leben* ‘life’, though certainly lexicalized to some degree, is usually used in the singular form unless referring to two entirely distinct lives, as in *Die Leben der beiden Politiker waren höchst unterschiedlich* ‘The two politicians’ lives were very different’. Compare, for example, the German movie titles *Die besten Jahre unseres Lebens_{SG}* and *Das Leben_{SG} der Anderen* with their English counterparts *The best years of our lives* and *The lives of others*. In ENHG, by contrast, the number of the abstract noun *Leben* tends to agree with the number of the possessive, as example (17) demonstrates.

- (17) *da sie in die Stadt dennoch wiederum kommen, und in ihren sündlichen **Leben** verharren, sollen sie an den Pranger gestäupet [...] werden*
‘if they come back to the city and persist in their sinful lives_{PL}, they shall be thrashed to the pillory’
(LEGA_P3_NoD_Rostock | GerManC)

Over time, then, *ung*-nominals tend to assume more features of prototypical nouns (cf. Hartmann 2014), which is why Demske (2002: 68) refers to the diachronic development of *ung*-nominalization as a “nominalization process with ‘nominalization’ taken literally”. While some Nominalized Infinitives are lexicalized, the word-formation pattern as such seems not to be as prone to lexicalization as *ung*-nominalization (cf. Barz 1998). Hence, the processual construal can still be seen as the default and prevalent one in the case of Infinitival Nominalization.

5. Conclusion

This paper has advocated a Cognitive-Linguistic and radically constructionist approach to word-formation change. I have argued that word-formation change is best accounted for in terms of con-

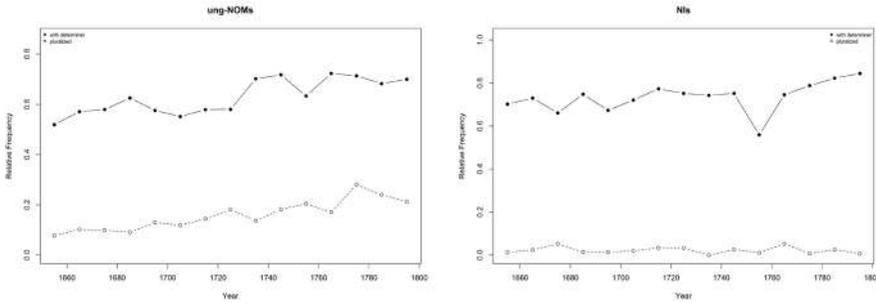


Fig. 9. Proportion of *ung*-nominals and NIs in a determiner construction or in the pluralized form, respectively, in relation to the total number of occurrences of each word-formation pattern. (Database: GerManC).

structions, i.e. form-meaning pairings at different levels of abstraction. However, constructional change at the morphological level does not happen in complete isolation from developments at other levels. In addition, each constructional change can have repercussions on other constructions. In the case of *ung*-nominalization and Infinitival Nominalization, a variety of factors can be assumed to interact.

First of all, it seems reasonable to assume that both patterns influence each other. Both a pull-chain scenario and a push-chain scenario are plausible, but given the complexity of the change processes and the variety of tightly intertwined factors, a combination of both seems most convincing: due to the more ‘nouny’ construal of *ung*-nominalizations, new NIs are coined to ‘replace’ some of the more processual *ung*-nominals – hence the increase in potential productivity that can be observed for Infinitival Nominalization. Due to these, in turn, the more ‘processual’ *ung*-nominals come out of use. As Werner (2010) has observed, Infinitival Nominalization seems to have experienced a loss of word-formation constraints. In earlier stages of German, NIs for punctual verbs such as *zerbrechen* ‘(to) break’ were not attested. In New High German, by contrast, Infinitival Nominalization can be applied to practically any verb. If Werner’s observation is correct, this loss of word-formation constraints can also be seen both as a reaction to the need for new NIs to replace the corresponding *ung*-nominals and as a ‘pushing’ development that is partly responsible for the *ung*-nouns in question to come out of use.

Furthermore, cultural factors certainly play a role in the diachronic development of *ung*-nominalization and competing word-formation patterns. For example, in the 17th and 18th centuries, one of

the oldest German word-formation patterns, namely implicit derivation, was ‘revived’: *ung*-nominals such as *Gebärung* ‘birth’ or *wach-sung* ‘growth’ were replaced by derivatives like *Geburt* or *Wuchs* (cf. Schmidt 2007: 153). This was in line with the emerging trend towards language ‘cultivation’ and language purism. As Wustmann (1903: 334) – a language purist himself – notes, *ung*-nominals were often perceived as an ugly-sounding ‘deformation’ of the language that should be avoided.

The diachronic change of German deverbal nominalization patterns can be seen as a highly complex and multi-faceted development at the interface of “cognition, culture and [language] use” (Bybee 2010: 194). The empirical findings corroborate the hypothesis that the prototypical meaning of *ung*-nominals has shifted towards a more ‘nouny’ construal, while Infinitival Nominalization is used to derive abstract nouns with a processual reading. Hence, the diachronic change of both patterns can also be interpreted as a case of functional re-organization in that Infinitival Nominalization comes to serve the same function as *ung*-nominalization did in earlier stages of German.

To be sure, the present study could only give a brief overview of the diachronic developments in question. Especially in the case of *ung*-nominalization, some aspects still merit further empirical investigation – for example, the rise of light-verb constructions such as *zur Aufführung bringen* ‘(to) perform, lit. bring to performance’ or the emergence of sentential nominalizations like *Inbetriebsetzung* ‘activation, lit. setting-into-procedure’. In addition, two closely intertwined questions should be addressed further: first, to what extent is the meaning of a word-formation product (or of a word in general) determined by the (syntactic) construction(s) in which it appears? The results of Zeschel’s (2012) study on intensifier constructions in English and German suggest that speakers’ generalizations over one and the same lemma are based on particular formal realizations of this element rather than all realizations of the lemma in aggregate (cf. Zeschel 2012: 231). Regarding the word-formation patterns investigated in the present study, an *ung*-nominal like *Ansehung* ‘view’ in its isolated form indeed seems to differ considerably from the same lemma used in a construction like *in Ansehung von* ‘with regard to; in view of’. Second, if this hypothesis is correct, the degree of ‘attraction’ or ‘repulsion’ between a specific syntactic construction and a specific *ung*-nominal might provide an important clue to differentiate various constructional subschemas (see section 2.1) on a quantitative basis.

The constructional approach outlined in this paper provides a useful framework for approaching these open questions.

Combining theoretical concepts and empirical approaches from (diachronic) Construction Grammar, Cognitive Grammar, and Cognitive Linguistics in general to study word-formation processes can yield new insights into the organization of language in the mind. However, it is equally important to this approach to emphasize that all aspects of language are deeply rooted in specific cultural and social-interactive settings. This in turn has important implications for the study of word-formation and word-formation change. As many examples throughout this paper have shown, research in word-formation must be decidedly usage-based rather than intuition-based. Taking cognitive and cultural factors into account helps to explain why word-formation patterns behave the way they do. Both the notion of constructional schemas and the tools developed in Cognitive Linguistics for semantic analysis can provide a deeper understanding of the functions of word-formation and the way in which word-formation patterns shape and modify the conceptual content of their bases. Thus, a cognitively oriented, usage-based and constructionist approach can prove highly valuable in charting new territories in the domains of word-formation and word-formation change.

Address of the Author

German Department, University of Mainz, Jakob-Welder-Weg 18, D-55099 Mainz, Germany<stefan.hartmann@uni-mainz.de>

Notes

¹ Specifically, the corpus was searched for forms ending in <ung(e)>, <u_g(e)>, <vng(e)>, <v_g(e)>, as well as <en>(the German infinitival suffix)ern>(as in the infinitival form '(to) celebrate' and the corresponding Nominalized Infinitive), <eln> (as in '(to) shake'), <e, <er>, and <el_>. <_> represents, in the transcription, a so-called 'nasal dash' above the preceding vowel indicating a subsequent /m/ or /n/ (cf. Nübling *et al.* 2012: 222). The nasal dash is a graphemic shortening device fairly common in this period and used until c. 1740 (cf. Ruge 2004: 219).

² In contrast to Present-Day German, *haltung* could be used in a semantically transparent meaning variant in the GerManC period, e.g. *zur besserer/ vnd richtiger haltung diser Ordnung!* 'for better and rightful observation of this order' (LEGA_P1_OOD_1659_SchulOrdnungRAW, GerManC); *Haltung der Tantz* 'conducting dances/dance events' (LEGA_P1_OMD_1680_DreszdenRAW.txt). Today, *Haltung* is largely restricted to the meanings of 'attitude' and 'posture', which are both completely dissociated from the meaning of the base verb *halten* '(to) hold'. In the two examples cited here, the prefixed variants *Einhaltung* 'observation' and *Abhaltung* 'conducting', respectively, would be preferred in Modern German.

³ An anonymous reviewer points to the so-called Level Ordering Hypothesis, which has been discussed, among others, by Siegel (1974) and Aronoff (1976). However, in the schema-based constructionist framework presented in this paper, the question which ordering relationships might apply between word-formation rules does not arise in the same way as in rule-based approaches. Instead, the problematic cases mentioned might be accounted for in terms of different constructional subschemas in Booij's (2010: 51-93) sense, which can in turn be arranged on a continuum ranging from [[Y]X-ung] to [[YX]-ung], as explained in the main text.

⁴ Taylor (2002: 291) actually describes schema salience as a function of type frequency, which is in line with the mainstream view in usage-based linguistics that only or at least predominantly the high type frequency of a construction contributes to its productivity (cf. the overview of different approaches to productivity in Zeschel 2012: 170-174). However, he does implicitly acknowledge the role of token frequency in stating: "All other things being equal, a schema which has a large number of different instances, none of which is itself particularly frequent, will be able to sanction new instances more readily than a schema with relatively few instances, each of which in itself may be quite frequent" (Taylor 2002: 291, emphasis added).

⁵ For example, Eisenberg (1994: 364) even calls *ung*-nominalization the most productive German word-formation pattern deriving abstract nouns.

⁶ In fact, we do find instances of *Erbblühung*, which both Demske (2000) and Shin (2002) consider ungrammatical, in actual language use, especially in the light-verb construction *zur Erblühung kommen*, e.g. "wenn nur dein Ich, deine Persönlichkeit, der Kern deines Wesens zur Erblühung kommt" 'if only your I, your personality, the essence of your character comes to blossom' (Paul Bülow, 1923, <http://www.aphorismen.de/zitat/111717>); but also "da möchten wir aber auch noch Bilder bei voller Erblühung sehen, jawohl ja!" 'but we also want to see pictures [of that flower] in full blossoming, oh yes!' (<http://gaertnerblog.de/blog/2012/agaven-blutete-in-hollabrunn/>); "Außerdem liebe ich einfach die Keimung des Liebeskornes zwischen Lily Evans und James Potter und die letztendliche Erblühung dieser herrlichen Blume" 'In addition, I just love the sprouting of the grain of love between Lily Evans and James Potter and the eventual blossoming of this marvelous flower' (<http://www.fanfiktion.de/u/mayjblack>). (All URLs retrieved 25/10/2013).

⁷ I use 'entity' in the broadest sense here, encompassing objects, persons, events, actions, states, etc.

⁸ Attestations that can be interpreted in both senses were disregarded in this analysis.

Bibliographical References

- ARONOFF Mark 1976. *Word Formation in Generative Grammar* (Linguistic Inquiry, Monographs 1). Cambridge, MA: MIT Press.
- BAAYEN R. Harald 1992. Quantitative aspects of morphological productivity. In BOOIJ Geert E. & Jaap VAN MARLE (eds.). *Yearbook of Morphology 1991*. Dordrecht: Kluwer. 109-149.
- BAAYEN R. Harald 1993. On frequency, transparency, and productivity. In BOOIJ Geert E. & Jaap VAN MARLE (eds.): *Yearbook of Morphology 1992*. Dordrecht: Kluwer. 181-208.
- BAAYEN R. Harald 2009. Corpus linguistics in morphology. *Morphological*

- productivity. In LÜDELING Anke & Merja KYTÖ (eds.). *Corpus Linguistics. An International Handbook. Vol. 2* (HSK 29.2). Berlin/New York: De Gruyter. 899-919.
- BARÐDAL Jóhanna 2008. *Productivity. Evidence from Case and Argument Structure in Icelandic* (Constructional Approaches to Language 8). Amsterdam/Philadelphia: John Benjamins.
- BARZ Irmhild 1998. Zur Lexikalisierungspotenz nominalisierter Infinitive. In BARZ Irmhild & Günther ÖHLSCHLÄGER (eds.). *Zwischen Grammatik und Lexikon*. Tübingen: Niemeyer. 57-68.
- BAUER Laurie 1983. *English Word Formation*. Cambridge: Cambridge University Press.
- BAUER Laurie 2001. *Morphological Productivity*. Cambridge: Cambridge University Press.
- BERGEN Benjamin K. 2012. *Louder than Words. The New Science of How the Mind Makes Meaning*. New York: Basic Books.
- BERGMANN Rolf & Dieter NERIUS 1998. *Die Entwicklung der Großschreibung im Deutschen von 1500 bis 1710*. Heidelberg: Winter.
- BOOLJ Geert E. 2010. *Construction Morphology*. Oxford: Oxford University Press.
- BOOLJ Geert E. 2012. *The Grammar of Words. An Introduction to Linguistic Morphology*. 3rd ed. Oxford: Oxford University Press.
- BRINTON Laurel J. & Elizabeth CLOSS TRAUGOTT 2005. *Lexicalization and Language Change*. Cambridge: Cambridge University Press.
- BYBEE Joan L. 2010. *Language, Usage and Cognition*. Cambridge: Cambridge University Press.
- CLAHSEN Harald, Ingrid SONNENSTUHL & James P. BLEVINS 2003. Derivational morphology in the German mental lexicon. A dual mechanism account. In BAAYEN R. Harald & Robert SCHREUDER (eds.). *Morphological Structure in Language Processing* (Trends in Linguistics. Studies and Monographs 151). Berlin/New York: De Gruyter. 125-155.
- CLAHSEN Harald & Kathleen NEUBAUER 2010. Morphology, frequency, and the processing of derived words in native and non-native speakers. *Lingua* 120. 2627-2637.
- COWIE Claire & Christiane DALTON-PUFFER 2002. Diachronic word-formation and studying changes in productivity over time. Theoretical and methodological considerations. In DÍAZ VERA Javier E. (ed.). *A Changing World of Words. Studies in English Historical Lexicography, Lexicology and Semantics*. Amsterdam/New York: Rodopi. 410-437.
- CROFT William 2001. *Radical Construction Grammar. Syntactic Theory in Typological Perspective*. Oxford: Oxford University Press.
- CROFT William 2012. *Verbs. Aspect and Causal Structure*. Oxford: Oxford University Press.
- CROFT William & Alan CRUSE 2004. *Cognitive Linguistics*. Cambridge: Cambridge University Press.
- DEMSKE Ulrike 1999. Nominalisierungen im Deutschen und Englischen. Überlegungen zu einer Theorie sprachlichen Wandels. In VOGEL Petra M. & Siegfried KANNGEISSER (eds.). *Elemente des Sprachwandels*. Opladen: Westdeutscher Verlag. 98-138.

- DEMSKE Ulrike 2000. Zur Geschichte der *ung*-Nominalisierung im Deutschen. Ein Wandel morphologischer Produktivität. *Beiträge zur Geschichte der deutschen Sprache und Literatur* 122. 365-411.
- DEMSKE Ulrike 2002. Nominalization and argument structure in Early New High German. In LANG Ewald & Ilse ZIMMERMANN (eds.). *Nominalisations* (ZAS Papers in Linguistics 27). Berlin: ZAS. 67-90.
- DIESSEL Holger 2004. *The Acquisition of Complex Sentences* (Cambridge Studies in Linguistics 105). Cambridge: Cambridge University Press.
- DRESSLER Wolfgang U. 1987. Word-formation (WF) as part of Natural Morphology. In DRESSLER Wolfgang U. (ed.). *Leitmotifs in Natural Morphology* (Studies in Language Companion Series 10). Amsterdam/Philadelphia: John Benjamins. 99-125.
- DURRELL Martin, Astrid ENSSLIN & Paul BENNETT 2007. The GerManC Project. *Sprache und Datenverarbeitung* 31. 71-80.
- FRIED Mirjam 2013. Principles of Constructional change. In HOFFMANN & TROUSDALE 2013. 419-437.
- GOLDBERG Adele E. 2006. *Constructions at Work. The Nature of Generalization in Language*. Oxford: Oxford University Press.
- HARTMANN Stefan 2013. Zwischen Transparenz und Lexikalisierung. Das Wortbildungsmuster X-*ung(e)* im Mittelhochdeutschen. *Beiträge zur Geschichte der deutschen Sprache und Literatur* 135. 159-183.
- HARTMANN Stefan 2014. The diachronic change of German nominalization patterns. An increase in prototypicality. In RUNDBLAD Gabriella, Aga TYTUS, Olivia KNAPTON & Chris TANG (eds.). *Selected Papers from the 4th UK Cognitive Linguistics Conference*. London: UK Cognitive Linguistics Association. 152-171.
- HARTMANN Stefan *to appear*. A Constructionist approach to the evolution of morphological complexity. In: *The Evolution of Language. Proceedings of the 10th International Conference*. Singapore: World Scientific.
- HILPERT Martin 2011. Was ist Konstruktionswandel? In LASCH Alexander & Alexander ZIEM (eds.). *Konstruktionsgrammatik III. Aktuelle Fragen und Lösungsansätze* (Stauffenburg Linguistik 58). Tübingen: Stauffenburg. 59-75.
- HILPERT Martin 2013. *Constructional Change in English. Developments in Allomorphy, Word Formation, and Syntax*. Cambridge: Cambridge University Press.
- HILPERT Martin & Stefan Th. GRIES 2009. Assessing frequency changes in multistage diachronic corpora. Applications for historical corpus linguistics and the study of language acquisition. *Literary and Linguistic Computing* 24. 385-401.
- HOFFMANN Thomas & Graeme TROUSDALE (eds.) 2013. *The Oxford Handbook of Construction Grammar*. Oxford: Oxford University Press.
- HOFFMANN Thomas & Graeme TROUSDALE 2013. Construction grammar. Introduction. In HOFFMANN & TROUSDALE 2013. 1-12.
- JACKENDOFF Ray 2010. The Parallel Architecture and its place in Cognitive Science. In HEINE Bernd & Heiko NARROG (eds.). *The Oxford Handbook of Linguistic Analysis*. Oxford: Oxford University Press. 583-605.
- JACKENDOFF Ray 2013. Constructions in the Parallel Architecture. In

- HOFFMANN & TROUSDALE 2013. 70-92.
- KASTOVSKY Dieter 1986. Diachronic word-formation in a functional perspective. In KASTOVSKY Dieter & Aleksander SZWEDEK (eds.). *Linguistics across Historical and Geographical Boundaries. Vol. 1: Linguistic Theory and Historical Linguistics* (Trends in Linguistics. Studies and Monographs 32.1). Berlin/New York: De Gruyter. 409-421.
- KNOBLOCH Clemens 2002. Zwischen Satz-Nominalisierung und Nennerivation. -ung-Nomina im Deutschen. *Sprachwissenschaft* 27. 333-362.
- LANGACKER Ronald W. 1987a. *Foundations of Cognitive Grammar. Vol. 1. Theoretical Prerequisites*. Stanford: Stanford University Press.
- LANGACKER Ronald W. 1987b. Nouns and verbs. *Language* 63. 53-94.
- LANGACKER Ronald W. 1988. A usage-based model. In RUDZKA-OSTYN Brygida (ed.). *Topics in Cognitive Linguistics* (Amsterdam studies in the theory and history of linguistic science 50). Amsterdam/Philadelphia: John Benjamins. 127-161.
- LANGACKER Ronald W. 1991a. *Concept, Image, and Symbol. The Cognitive Basis of Grammar* (Cognitive Linguistics Research 1). Berlin/New York: De Gruyter.
- LANGACKER Ronald W. 1991b. *Foundations of Cognitive Grammar. Vol. 2. Descriptive Application*. Stanford: Stanford University Press.
- LANGACKER Ronald W. 1996. Viewing in cognition and grammar. In DAVIS Philip W. (ed.). *Alternative Linguistics. Descriptive and Theoretical Modes* (Current Issues in Linguistic Theory 102). Amsterdam/Philadelphia: John Benjamins. 153-212.
- LANGACKER Ronald W. 2008. *Cognitive Grammar. A Basic Introduction*. Oxford: Oxford University Press.
- MATLOCK Teenie 2001. The conceptual motivation of aspect. In RADDEN Günter & Klaus-Uwe PANTHER (eds.). *Motivation in Grammar and the Lexicon* (Human Cognitive Processing 27). Amsterdam/Philadelphia: John Benjamins. 133-147.
- MATLOCK Teenie, David SPARKS, Justin L. MATTHEWS, Jeremy HUNTER & Stephanie HUETTE 2012. Smashing new results on aspectual framing. How people talk about car accidents. *Studies in Language* 36. 700-721.
- MATLOCK Teenie & Bodo WINTER *to appear*. Experimental semantics. In HEINE Bernd & Heiko NARROG (eds.). *The Oxford Handbook of Linguistic Analysis*. 2nd ed. Oxford: Oxford University Press.
- NÜBLING Damaris, Antje DAMMEL, Janet DUKE & Renata SZCZEPANIAK 2012. *Historische Sprachwissenschaft des Deutschen. Eine Einführung in die Prinzipien des Sprachwandels*. 4th ed. Tübingen: Narr.
- PANTHER Klaus-Uwe & Linda THORNBURG 2001. A conceptual analysis of English -er nominals. In PÜTZ Martin, Susanne NIEMEIER & René DIRVEN (eds.). *Applied Cognitive Linguistics. Vol. 2: Language Pedagogy* (Cognitive Linguistics Research 19.2). Berlin/New York: De Gruyter. 149-200.
- PAUL Hermann [1920] 1968. *Deutsche Grammatik. Bd. V: Wortbildungslehre*. Tübingen: Niemeyer.
- PLAG Ingo 1999. *Morphological Productivity. Structural Constraints in English Derivation* (Topics in English Linguistics 28). Berlin/New York:

De Gruyter.

- PLEYER Michael 2012. Cognitive construal, mental spaces and the evolution of language and cognition. In SCOTT-PHILLIPS Thomas C., Mónica TAMARIZ, Erica A. CARTMILL & James R. HURFORD (eds.). *The Evolution of Language. Proceedings of the 9th International Conference*. Singapore: World Scientific. 288-295.
- ROELCKE Thorsten 1998. Die Periodisierung der deutschen Sprachgeschichte. In BESCH Werner, Anne BETTEN, Oskar REICHMANN & Stefan SONDEREGGER (eds.). *Sprachgeschichte. Ein Handbuch zur Geschichte der deutschen Sprache und ihrer Erforschung. Bd. 1*. 2. Aufl. Berlin/New York: De Gruyter. 798-815.
- RÖMER Christine 1987. Transformationalistische und lexikalistische Erklärung von Wortbildungen – dargestellt am Beispiel deverbalen -ung-Substantive. *Deutsch als Fremdsprache* 24. 217-221.
- ROSSDEUTSCHER Antje 2010. German -ung-Nominalisation. An explanation of formation and interpretation in a root-based account. In OLSEN Susan (ed.). *New Impulses in Word-Formation* (Linguistische Berichte; Sonderheft 17). Berlin/New York: De Gruyter. 101-132.
- ROSSDEUTSCHER Antje & Hans KAMP 2010. Syntactic and semantic constraints on the formation and interpretation of -ung-nouns. In RATHERT Monika & Artemis ALEXIADOU (eds.). *The Semantics of Nominalizations across Languages and Frameworks* (Interface Explorations 22). Berlin/New York: De Gruyter. 169-214.
- RUGE Nikolaus 2004. *Aufkommen und Durchsetzung morphembezogener Schreibungen im Deutschen 1500-1770*. Heidelberg: Winter.
- SALMONS Joseph 2012. *A History of German. What the Past Reveals about Today's Language*. Oxford: Oxford University Press.
- SCHERER Carmen 2005. *Wortbildungswandel und Produktivität. Eine empirische Studie zur nominalen er-Derivation im Deutschen* (Linguistische Arbeiten 497). Tübingen: Max Niemeyer.
- SCHERER Carmen 2006. Was ist Wortbildungswandel? *Linguistische Berichte* 205. 3-28.
- SCHERER Wilhelm 1890. *Zur Geschichte der deutschen Sprache*. 2nd ed. Berlin: Duncker.
- SCHMIDT Wilhelm 2007. *Geschichte der deutschen Sprache. Ein Lehrbuch für das germanistische Studium*. 10th ed. Stuttgart: Hirzel.
- SHIN Soo-Song 2001. On the event structure of -ung-nominals in German. *Linguistics* 39. 297-319.
- SIEGEL Dorothy 1974. *Topics in English Morphology*. Ph.D. Dissertation. Brandeis University, Waltham, MA.
- SPENCER Andrew 1988. Bracketing paradoxes and the English lexicon. *Language* 64. 663-682.
- TAYLOR John R. 2002. *Cognitive Grammar*. Oxford: Oxford University Press.
- TAYLOR John R. 2012. *The Mental Corpus. How Language is Represented in the Mind*. Oxford: Oxford University Press.
- TRAUGOTT Elizabeth Closs 2008. Grammaticalization, constructions and the incremental development of language. Suggestions from the develop-

- ment of degree modifiers in English. In ECKHART Regine, Gerhard JÄGER & Tonjes VEENSTRA (eds.). *Variation, Selection, Development. Probing the Evolutionary Model of Language Change* (Trends in Linguistics. Studies and Monographs 197). Berlin/New York: De Gruyter. 219-250.
- TRAUGOTT Elizabeth Closs & Graeme TROUSDALE 2013. *Constructionalization and Constructional Changes* (Oxford Studies in Diachronic and Historical Linguistics 6). Oxford: Oxford University Press.
- TROUSDALE Graeme 2008. A Constructional approach to lexicalization processes in the history of English. Evidence from possessive constructions. *Word Structure* 1. 156-177.
- VERHAGEN Arie 2007. Construal and perspectivization. In GEERAERTS Dirk & Hubert CUYCKENS (eds.). *The Oxford Handbook of Cognitive Linguistics*. Oxford: Oxford University Press. 48-81.
- VERSPoor Marjolijn 1996. The story of -ing: A subjective perspective. In PÜTZ Martin & René DIRVEN (eds.). *The Construal of Space in Language and Thought* (Cognitive Linguistics Research 8). Berlin/New York: De Gruyter. 417-454.
- VOGEL Petra M. 1996. *Wortarten und Wortartenwechsel. Zur Konversion und verwandten Erscheinungen im Deutschen und in anderen Sprachen* (Studia Linguistica Germanica 39). Berlin/New York: De Gruyter.
- WERNER Martina 2010. Substantivierter Infinitiv statt Derivation. Ein ‚echter‘ Genuswechsel und ein Wechsel der Kodierungstechnik innerhalb der deutschen Verbalabstraktbildung. In BITTNER Dagmar & Livio GAETA (eds.). *Kodierungstechniken im Wandel. Das Zusammenspiel von Analytik und Synthese im Gegenwartsdeutschen* (Linguistik – Impulse und Tendenzen 34). Berlin/New York: De Gruyter. 159-178.
- WUSTMANN Gustav 1903. *Allerhand Sprachdummheiten. Kleine deutsche Grammatik des Zweifelhafte[n], des Falsche[n] und des Häßliche[n]*. 3rd ed. Leipzig: Grunow.
- ZESCHEL Arne 2012. *Incipient Productivity. A Construction-Based Approach to Linguistic Creativity* (Cognitive Linguistics Research 49). Berlin/New York: De Gruyter.
- ZIEM Alexander & Alexander LASCH 2013. *Konstruktionsgrammatik. Konzepte und Grundlagen gebrauchsbasierter Ansätze*. Berlin/New York: De Gruyter.

Stefan Hartmann

CORPORA	
COSMAS II	http://www.ids-mannheim.de/cosmas2/
DeReKo	German Reference Corpus, available via COSMAS II
COSMAS II- HIST	COSMAS II's archive of historical corpora
DWDS	Digitales Wörterbuch der deutschen Sprache (Digital German Dictionary), http://www.dwds.de
GerManC	http://www.llc.manchester.ac.uk/research/projects/germanc/
MzENHG	Mainz Early New High German Corpus (yet unpublished)

Software

- Anthony, Laurence 2011. AntConc 3.2.4. Tokyo, Japan: Waseda University. <http://www.antlab.sci.waseda.ac.jp/> (last checked 23/10/2013).
- R Core Team 2013. R. A Language and Environment for Statistical Computing. Vienna: R Foundation for Statistical Computing. <http://www.R-project.org> (last accessed 23/10/2013).