

## LEXICAL DATABASE, DERIVATIONAL MAP AND 3D REPRESENTATION<sup>1</sup>

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**ABSTRACT.** *This article focuses on the relationship between a lexical database and a derivational map, a hierarchical representation of the lexicon that specifies lexical and morphological inheritance by means of graph theory. In order to take steps towards constructing a three-dimensional lexicon, this article also puts forward the concept of semantic pole. A semantic pole is a pivot of lexical organization defined as the area of lexical space comprised of the intersection of the lexical areas of one or more derivational paradigms and the major exponents of a semantic prime. This proposal is applied to the semantic pole *sōð-trēowe* in Old English and two main conclusions are reached. Firstly, a semantic pole constitutes a panchronic representation of lexical relations that contributes to the development of the third-generation Internet, which aims, among other things, at compiling databases and representing contents in 3D. Secondly, the concept of semantic pole constitutes an explanatory principle of derivational morphology and lexical semantics because it explains the degree of convergence between morphological and lexical inheritance, accounts for the clustering of lexical items around certain semantic poles and predicts the rise of polysemy.*

**KEYWORDS.** *Lexical database, derivational map, 3D linguistic representation, dynamic lexical space, semantic pole, semantic prime, lexical prime.*

**RESUMEN.** *Este artículo versa de la relación existente entre una base de datos léxica y un mapa derivativo o representación jerárquica del léxico que representa la herencia léxica y morfológica por medio de la teoría de grafos. A fin de avanzar hacia la construcción de un lexicon tridimensional, este artículo también propone el concepto de polo semántico. Un polo semántico es un pivote de la organización léxica que se define como el área del espacio léxico comprendida por la intersección de las áreas de uno o más paradigmas derivativos y de los exponentes principales de un primitivo semántico. Esta propuesta se aplica al polo semántico *sōð-trēowe* del inglés antiguo y se llega a dos conclusiones principales. En primer lugar, un polo semántico constituye una representación pancrónica de las relaciones léxicas que contribuye al desarrollo del internet de tercera generación, que se propone, entre otros objetivos, elaborar bases de datos y representar contenidos en 3D. Segundo, el concepto de polo semántico representa un principio explicativo de la morfología derivativa y la semántica léxi-*

*ca porque es capaz de dar cuenta del grado de convergencia entre la herencia morfológica y léxica, explicar la concentración de ítems léxicos alrededor de ciertos polos semánticos y predecir la aparición de la polisemia.*

PALABRAS CLAVE. Base de datos léxica, mapa derivativo, representación lingüística en 3D, espacio léxico dinámico, polo semántico, primitivo semántico, primitivo léxico.

## 1. INTRODUCTION

The aims of the *Nerthus* Project ([www.nerthusproject.com](http://www.nerthusproject.com)) are to provide an overall analysis of the Old English lexicon based on up-to-date linguistic theory and to incorporate the findings of lexicological analysis into a lexicographical product that meets 21<sup>st</sup> century lexicographical standards. The relevance of the undertaking lies on the descriptive and applied aspects that are discussed in turn. On the lexicological side, in spite of the width and breadth of previous research by authors like Kastovsky (1992) and Lass (1994), it remains to conduct an exhaustive study that acknowledges the pride of place of derivational morphology in the lexicon of a language such as Old English, whose lexical stock is consistently and almost exclusively Germanic. Such a lexicological analysis will settle some of the pending questions in the field, which include the lexical vs. morphological status of some affixes, the nature and function of alternations, the interaction of derivational processes of zero derivation, compounding and affixation, the productivity of affixes and the lexicalization of derivatives, among others. Moreover, the lexicology of Old English is in much need of a survey that suitably combines the synchronic and diachronic data that conform the vocabulary of this stage of the English language. In this respect, previous research has concentrated on verbal prefixation, to take issue with the progressive loss of functionality of the Germanic prefixes (de la Cruz 1973; Horgan 1980; Hiltunen 1983; Kastovsky 1992) and the grammaticalization of adverbs and prepositions (Brinton 1986; Brinton and Traugott 2005), but other questions remain practically untouched, including aspects of word-formation such as the alternations displayed by categories different from the noun and the derivation not based on strong verbs; and more semantically oriented topics like lexical inheritance in the derivational paradigm.

On the side of applications, the standard dictionaries of Old English, including *An Anglo-Saxon Dictionary* (Bosworth and Toller 1973), *The Student's Dictionary of Anglo-Saxon* (Sweet 1976) and *A Concise Anglo-Saxon Dictionary* (Clark Hall 1996), are based on 19th century lexicographical practice, thus providing a wealth of philological data but coming short in terminological rigour and analytical systematicity. The Old English lexicographical works that have appeared recently or are currently in progress represent a huge advance with respect to the lexicography of the turn of the 20th century but are not without problems. The strongholds of *The Dictionary of Old English* (Healey 2008) are exhaustiveness and accuracy, both guaranteed by computer implementation and corpus analysis involving the design and compilation of the authoritative *Dictionary of Old English Corpus* (Healey *et al.* 2004). However, *The Dictionary of Old English*,

which probably constitutes the leading project in the field of Anglo-Saxon studies, has just reached the letter G, with which the community of Anglo-Saxonists will have to wait for some years before a complete product is available. Apart from this question, *The Dictionary of Old English* shares with *A Thesaurus of Old English* (Roberts and Kay 1995) the concern with the art and craft of the lexicographical tradition that renders these works incompatible, without further analysis, with linguistic formalization. To illustrate this point, it suffices to underline the notional character of the semantic dimensions and fields defined by *The Thesaurus of Old English* and the recently published *Historical Thesaurus of The Oxford English Dictionary* (Kay et al. 2009). Along with the advances of the *Nerthus* Project expected in these areas, theoretical conclusions will be drawn from the lexicological analysis and lexicographical applications regarding meaning construction, the paradigmatic organization of the lexicon and the role of word-formation in grammatical theory.

Against this background, this article reports on previous advances of the project and proposes a new database design. More specifically, it puts forward the concept of *derivational map* and lays the foundations of a three-dimensional concept of the lexicon. Section 2 describes the lexical architecture of the database of Old English *Nerthus* as resulting of the application of the Principle of Lexical Proto-Grammar and the Principle of the Targets of Derivation. Then, Section 3 develops the concept of derivational map, which constitutes a hierarchical representation of the lexicon that specifies lexical and morphological inheritance by means of graph theory. Section 3 also displays the 3D interface of a derivational map. Section 4 advances a proposal for the concept of semantic pole, understood as a panchronic representation of lexical relations compatible with a 3D lexicon. To close this article, Section 5 summarizes the main conclusions of the research.

## 2. THE DESIGN OF THE LEXICAL DATABASE OF OLD ENGLISH *NERTHUS*

The *Nerthus* Project has opted for the database format in order to compile and give access to morphological and lexicological information on Old English. This format has been chosen because a lexical database has several advantages over a dictionary. To begin with, a lexical database is versatile, given that it can be modified or expanded easily and, as a result, serve various functions or give rise to several lexicographical products. Furthermore, the design of a lexical database requires a neatly defined set of units and relations, which certainly contributes to the rigour and exhaustiveness of the final product. Even more importantly, lexical databases, by following in the track of *WordNet* (Fellbaum 1998), stress the hierarchical organization of the lexicon on the syntagmatic and the paradigmatic axis through lexico-semantic relations such as hyperonymy and hyponymy. This means that lexical databases can be interpreted and used as ontologies of the languages under analysis. Ontologies, in turn, provide a solid point of contact with state-of-the-art research in semantics, cognitive sciences, computation and the semantic web. For these reasons, the *Nerthus* Project has opted for

designing and compiling a lexical database that applies the findings of the morphological and lexicological study of Old English. For the sake of dissemination, the lexical database can be accessed online by a web browser and searched with several query options.

The initial headword list of the lexical database of Old English Nerthus is based on the entries to *A Concise Anglo-Saxon Dictionary* (Clark Hall 1996) and the lexicological information provided by this dictionary as well as *An Anglo-Saxon Dictionary* (Bosworth and Toller 1973) and *The Student's Dictionary of Anglo-Saxon* (Sweet 1976). On specific questions, *The Dictionary of Old English* (Healey 2008) has been consulted, while many decisions concerning morphological relatedness have been made on the grounds of the data gathered by *The Dictionary of Old English Corpus* (Healey *et al.* 2008). The etymological part (Proto-Germanic) draws on several sources, among which Seebold (1970), Heidermanns (1993) and Orel (2003) deserve special mention. Sweet's (1976) *Student's Dictionary of Anglo-Saxon* has also been very helpful with etymology, given the archaic stage of the language that this dictionary tries to reflect<sup>2</sup>.

The database contains 29,987 headwords currently, which can be classified by category as can be seen in Table 1<sup>3</sup>:

TABLE 1. Nerthus *headwords by category*.

Category	Headwords
<b>Major lexical classes</b>	
Noun	16,690
Adjective	5,785
Verb	5,618
Adverb	1,654
<b>Minor lexical classes</b>	
Adposition	80
Numeral	52
Pronoun	39
Conjunction	38
Interjection	21
Demonstrative/Article	8
Possessive	3
Total	29,987

By initial letter, the headwords of *Nerthus* are distributed as shown by Table 2:

TABLE 2. *Nerthus* headwords by initial letter.

A 1,376	Æ 581	B 1,853	C 1,074	D 634
E 1,155	F 2,537	G 2,629	(GE-) 1,457	H 2,489
I 370	L 974	M 1,268	N 568	O 1,288
P 296	R 565	S 2,866	T 990	Ð 747
U 1,790	V 1	W 2,224	Y 255	

On the grounds of the lexical inventory comprised by the headword list described by Table 1 and Table 2, the morphological and lexicological research carried out by the *Nerthus* Project is based on two general principles of explanatory character, namely the Principle of Lexical Proto-Grammar (PLPG) and the Principle of the Targets of Derivation (PTD). The PLPG stipulates that word-formation units constitute a lexical proto-grammar from which significant syntactic and semantic generalizations can be made. This principle has been inspired by previous work in the structural-functional tradition of linguistics, as represented by Dik's (1997a, 1997b) Functional Grammar, Van Valin and LaPolla's (1997) and Van Valin's (2005) Role and Reference Grammar and Hengeveld and Mackenzie's (2008) Functional Discourse Grammar. These linguistic theories, in spite of the differences of scope and orientation that arise among them, share a rich description of lexical items that guarantees the projection of syntactic structures and the linking with semantics<sup>4</sup>. Within this setting, the PLPG has been developed by a number of publications (Martín Arista 2008, 2009, 2011a) that put forward a model of word structure that emphasizes the points of contact of derivational morphology with syntax and lexical semantics. As a brief illustration, consider the class of weak verbs that derive from adjectives and hold a stative-non stative (ingressive) alternation, including *dimmian* 'to be or become dim', *fūlian* 'to be or become foul', *heardian* 'to be or become hard', *hāsian* 'to be or become hoarse', etc.<sup>5</sup> The logical structures of these verbs contain the adjectival base of derivation, as is the case with *dimm* 'dim' and *dimmian* 'to be or become dimm'.

The PTG requires that the units of description are the targets rather than the sources of derivation, that is, the direction of derivation goes from unanalysable (simplex) to analysable (complex) lexical items. So as to focus on the targets of derivation, it is necessary to compile an inventory of headwords that highlights morphological contrast and relatedness. Thus, headword definition is governed by a principle of formal maximization in terms of which formal similarities and differences of morphological relevance are stressed. To this purpose, numbered entries have been devised, on the grounds of different category, different morphological class or different variants, for

predicates otherwise equal. For instance, *besēon* 1 ‘to see, look, look round’, is a class V strong verb, whereas *besēon* 2 ‘to suffuse’ belongs to class I<sup>6</sup>.

The PTG has been adopted with a view to defining the derivational paradigms and layers that configure the vocabulary of Old English (Martín Arista 2011b). Derivational paradigms and layers are presented in more detail in Section 3. For the time being, it suffices to say that a derivational paradigm is a set of derivatives that share a base of derivation, while layers draw a distinction between more productive and less productive derivational processes. The stepwise representation of lexical creation is mirrored by the definition of meanings, which also proceeds from more nuclear meanings to more peripheral meanings. This can be seen, for instance, in the progressive meaning specialization of the derivatives of the strong verb (class I) *drīfan* ‘to drive’, which include the zero derived *drāf* (feminine) ‘action of driving’, the prefixed *ūdrāf* (feminine) ‘decree of expulsion’ and the suffixed *tōdrāfednes* (feminine) ‘dispersion’. Morphological inheritance and lexical inheritance meet in the translation of items like *faran*, which stages two lexical primes and hyperonymic terms marked by capital letters: ‘to GO, proceed, travel, to set forth, march, sail; to FARE, happen, undergo, suffer; move, wander’.

Throughout the process of analysing the lexicon of Old English with the aim of identifying lexical primes and gathering their derivational paradigms, the issue frequently arises of how many primes to define. The decision adopted on this question has consequences of chief importance for an overall explanation of the lexicon since the inventory of paradigms constitutes, along with a principled description of the morphological and lexical relations holding on the synchronic axis, a diachronic hypothesis on the evolution of lexical form and meaning. The identification of lexical primes is restricted by the continuity constraint, which can be formulated in these terms: lexical paradigms are continuous formally and semantically. In this constraint, continuity is used with the sense of *relatedness*, which, on the phonological side, is mainly explained on the grounds of *i*-mutation. From the morphological perspective, relatedness is justified by the possible morphological processes undergone by lexical categories, as well as the restrictions on these processes. Finally, as far as semantics is concerned, relatedness is mainly explained by means of lexically motivated hyperonymy. For instance, there is remarkable meaning continuity between the strong verb (class VIIg) *(ge)būgan* ‘to stay, dwell, live; lie (of land); inhabit, occupy; cultivate’ and the neuter noun *būr* ‘bower, apartment, chamber; storehouse, cottage, dwelling’, the change in meaning being attributable to the re-categorization verb-noun and the assignment of the derivational function LOC(ative). On the other hand, a new lexical paradigm has been secreted when formal and semantic discontinuities appear between two sections of a candidate for lexical prime. Paradigmatic split is restricted by the zero derivation constraint, which requires that the two lexical paradigms have zero derivatives. For example, some formal and semantic features of *blæd* 1 ‘blowing, blast; inspiration; breath, spirit; life, mind; glory, dignity, splendour; prosperity, riches, success’ cannot be inherited from *(ge)blāwan* ‘to blow, breathe; be blown, sound; inflate’ and, considering that the former exhibits zero derivatives

of its own, two lexical primes have been defined. Table 3 displays the number of lexical primes that have been identified by following the premises outlined above.

TABLE 3. *Lexical primes by category.*

Category	Lexical primes
Noun	1,741
Adjective	366
Strong verb	344
Weak verb	260
Adverb	80
Total	2,791

To summarize, the lexical database of Old English Nerthus offers an exhaustive description of the lexicon as well as an explanation for this linguistic component based on hierarchy (prime vs. non-prime) and inheritance (exponent of paradigm vs. non-exponent of paradigm). The next section takes issue with the question of how to turn a lexical database with the specifications just given into a derivational map with an explicit geometry that unfolds an ontology of concepts and relations.

### 3. DRAWING A DERIVATIONAL MAP

A derivational map is a visual representation of the relations of inheritance holding among lexical items. Such a representation displays two main characteristics: exhaustivity and gradualness. With these premises, the geometry of a derivational map is provided by graph theory. A graph is a mathematical structure that specifies the relations that obtain among the members from a set.

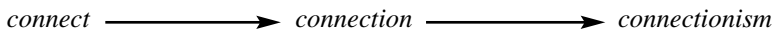


Figure 1. *Recursive derivation as a diagraph with adjacent vertices.*

In graph theory, a graph is comprised of a set of nodes or vertices connected by edges or arcs. In Figure 1, each lexical item constitutes a node while arrows (or edges) mark morphological and lexical inheritance resulting from word-formation. As can be seen in Figure 1, lexical inheritance goes from the base of derivation to the derivative rather than the other way around. Therefore, the edges are directed towards the derivative. In graph theory, such a graph with directed edges is called a *diagraph*. In the diagraph in Figure 1, the node *connect* is the initial vertex, while the node *connectionism* is the terminal vertex. The derivational history of a word, consisting of

all steps of derivation previous to the final derivation that turns out the recursive derivative (*connect* > *connection* > *connectionism*) can be construed as a path or sequence of consecutive edges in which the depth of the derivation is accounted for in terms of the number of edges traversed. The gradual character of derivations is guaranteed by the requisite that stipulates that morphological process of word-formation apply in a stepwise way, giving rise to adjacent vertices, that is, vertices that are connected by one edge.

This concept of derivational map elaborates on the semantic maps proposed by Haspelmath (2003) and François (2008), oriented, respectively, towards grammatical functions and polysemy. According to Haspelmath (2003: 13) “a semantic map is a geometrical representation of functions in ‘conceptual/semantic space’ that are linked by connecting lines and thus constitute a network”. Gaume *et al.* (2008: 238) distinguish three types of lexical networks, namely syntagmatic relations of cooccurrence in a corpus, paradigmatic relations such as synonymy and relations of semantic proximity between two words when one is found in the definition of the other. To this inventory a fourth relation can be added, namely the lexical relation of derivation, whereby complex words can be traced back to their corresponding simplexes. The acknowledgement of the lexical relation of derivation is a consequence of the central role that word-formation plays in the organization of the lexicon and the convergence of hyponymy and derivation. These aspects are undoubtedly more outstanding in a language such as Old English, in which, as pointed out above, the lexical stock is native and suffused by associative relations. To the extent that morphological inheritance is convergent with lexical inheritance, a derivational map explains not only the progressive enrichment of the lexicon by means of word-formation processes but also the gradual specialization of more derived lexical items with respect to less derived ones. Put differently, lexical hierarchies based on morphological inheritance constitute an explanatory principle of paramount importance for the general structure and organization of the lexicon of a language. It follows that the more central word-formation is to the outfit of the lexicon (with the corresponding smaller weight of lexical borrowing), the more morphological and lexical inheritance converge.

A derivational map is encoded with respect to an ontology that represents a conceptual model of the lexical domain of language. Following Gruber (1993: 907), the term *ontology* is used with the meaning of *explicit specification of a conceptualization*. Ontologies, in this view, are *conceptual schemata, intended to represent knowledge* (Kiryakov 2006: 117). The ontology of a derivational map comprises two modules with a set of classes representing concepts relevant to the lexical domain of language (the Metalinguistic Module and the Linguistic Module) as well as a set of relations holding between those classes. In the Metalinguistic Module, the concept of Lexical Category refers to word classes, including free classes of the lexical type (Noun, Adjective, Verb and Adverb), free classes of the grammatical type (Adposition, Article-Demonstrative, Pronoun, Numeral and Possessive) and the bound



class of the Affix (further divided into Prefix and Suffix). Also within the Metalinguistic Module, the concept of Entry entails a basic distinction between Unlemmatised Form and Lemmatised Form, which can be broken down into Headword and Phonological Variant, both subdivided into Numbered and Non Numbered. The concept of Translation makes reference to the equivalent of a lexical item in another language or linguistic stage. Finally, the concept of alternation makes reference to recurrent contrasts holding in morphophonology. This concept belongs to the Metalinguistic Module if morphophonological alternations are not productive and, as a result, have to be identified or reconstructed through linguistic analysis. On the other hand, if morphophonological alternations are fully operative, in such a way that a contrast of form is matched by a systematic contrast of meaning, they partake in the Linguistic Module. The main relation that obtains in the Metalinguistic Module is *X belongs to class Y* (Lexical category), which assigns a lexical item to a lexical category. Other relations of this module are *X is a token of type Y* (Entry), which relates unlemmatised forms to lemmatised ones, *X translates as Y* (Translation), relating a term to its translation into Present-day English, and *X is an alternant form of Y* (Alternation), linking morphophonologically contrasting forms. In the Linguistic Module, the key concept is that of Process, which is divided into Inflection and Derivation. Derivation is subdivided into Non Recursive Derivation (comprising Zero Derivation only) and Recursive Derivation, which can be broken down into Compounding and Affixation (Prefixation and Suffixation).

Process is not a function of Lexical Category because the distinction between free and bound forms separates compounding from affixation, but not zero derivation. The second concept of the Linguistic Module is Function, in terms of which the process of Inflection serves a certain Inflectional Function (Case, Gender, Number, Person, Tense, Mood, etc.) and, conversely, the process of Derivation performs a given Derivational Function (Telicity, Locality, Modification, Quantification, Negation, etc.). Realization is the third concept that belongs in the Linguistic Module and relates semantic non-primes to semantic primes. The concept of hyponymy accounts for meaning constants throughout lexical derivation. Finally, the concept of allomorphy subcategorizes abstract morphemes. The relations that hold in the Linguistic Module include *X is an inflectional form of Y*, which ascribes a lexical item to its inflectional paradigm, *X is a derivative of Y*, identifying the base of derivation of a lexical item (Process); *X performs the inflectional function Y*, *X performs the derivational function Y*, which provide a principled inventory of inflectional and derivational relations (Function); *X is an exponent of Y*, which relates an exponent to its semantic prime (Realization); *X is a hyponym of*, which ascribes a given lexical items to its hyperonymic term (Hyponymy); and *X is an allomorph of Y*, which defines phonologically conditioned forms (Allomorphy). Figure 2 represents the two modules just described:

<b>Metalinguistic Module</b>	
<u>Concepts</u>	<u>Relations</u>
Lexical category	<i>X belongs to category Y</i>
Entry	<i>X is a token of type Y</i>
Translation	<i>X translates as Y</i>
Alternation	<i>X is an alternant form of Y</i>

<b>Linguistic Module</b>	
<u>Concepts</u>	<u>Relations</u>
Process	<i>X is an inflectional form of Y</i> <i>Y is a derivative of X</i>
Function	<i>X performs the inflectional function Y</i> <i>X performs the derivational function Y</i>
Realization	<i>X is an exponent of Y</i>
Hyponymy	<i>X is a hyponym of Y</i>
Allomorphy	<i>X is an allomorph of Y</i>

Figure 2. *Informal ontology of a derivational map.*

To recapitulate, in this proposal for a derivational map, graph theory provides the geometry of the model, in such a way that the lexical inventory is represented as a set of nodes, while lexical and morphological inheritance, specified by an ontology in terms of concepts and relations, are represented as a set of edges. Such edges ultimately instantiate two concepts that endow the lexicon with a hierarchical organization both on the morpho-lexical side (word-formation) and the lexico-semantic side (hyponymy), namely lexical primes and lexical layers. A derivational paradigm is defined by a motivated set of lexical and morphological relations of inheritance. The concept of derivational elaborates on Pounder (2000), for whom a paradigm comprises all the lexical items that can be morphologically and lexically related to a given lexemic root, so that the product of derivation constitutes the lexical paradigm while the dynamic operation of derivational processes represents the morphological paradigm. Lexical layers account for the coexistence in the lexicon of the output of both unproductive and productive processes of word-formation. As an illustration of the concept of derivational paradigm, take the class VI strong verb

*bacan* ‘to bake’ and its affixal derivatives *ābacan* (strong VI) ‘to bake’, *bæcere I* (masculine) ‘baker’, *bæcering* (masculine) ‘gridiron’ and *bæcestre* (feminine) ‘female baker’, all of which hold a morphological and lexical relation of inheritance with the strong verb, which constitutes the direct or indirect base of derivation of these complex words and contributes a constant meaning. For instance, in the derivational paradigm of *bacan* ‘to bake’ the derivatives *bæcere I* (masculine) ‘baker’ and *bæcestre* (feminine) ‘female baker’ make reference to ‘one who bakes’. As for layers, the output of the unproductive process of zero derivation represents a lexical sub-stratum on which the stratum containing the output of productive processes of word-formation rests. The relationship obtaining between these layers, however, is not simply one of addition. Rather, the layer of zero derivation often provides the base of derivation of productive processes. An instance in point is found in the derivational paradigm of the strong verb (class IIIb) *ābelgan* ‘to make angry’, which has two zero derivatives, the weak verb (class 1) *ābylgan* ‘to irritate’ and the noun *ābylg* ‘anger’. These, in turn, are the bases of derivation for the suffixal nouns *ābylgnes* ‘offence’ and *ābylgð* ‘anger’. Put differently, the derivation of complex words is defined gradually, each morphological process (affixation, compounding and zero derivation) attaching a maximum of one element to the base. That is, the term *recursivity* in this approach is used in the standard way to indicate that an affix is attached to an already derived base. However, the analysis of Old English word-formation has evidenced that recursivity turns up not only in combinations of semantically compatible affixes such as *þearf-ednes* ‘poverty’, *þearf-lēas-e* ‘needlessly’ and *þearf-end-līce* ‘poorly’ but also in derivations that cause no meaning change, as is the case with the second member of the following pairs with respect to the first one: *unālȳfed/unālȳfedlic* ‘illicit’, *unāmeten/unāmetenlic* ‘unmeasured’ and *oferflōwend/ oferflōwendlic* ‘excessive’. That is, recursivity entails progressive meaning specialization in instances like *brōðor* ‘brother’ > *brōðorlīc* ‘brotherly’ > *brōðorlīcnes* ‘brotherliness’, as well as the replacement of an unproductive process of word formation (zero derivation) with a productive process (affixation), as in *nytt/nyttol* ‘useful’ (< *nēotan* ‘to use’, strong II), *oflyst/oflysted* ‘desirous’ (< *lust* ‘desire’) and *flīemanfeorm/flīemanfeorming* ‘offence of sheltering fugitives’ (< *feorm* ‘provision, sustenance’).

José Manuel Valle Melón and Álvaro Rodríguez Miranda (Laboratorio de documentación geométrica del patrimonio, Universidad del País Vasco) have implemented the three-dimensional model of the derivational map with XGLORE, a 3D graph explorer whose nodes are placed in 3D space relative to their level from the root node so that child nodes are arranged centrifugally around the parent node. The semantic map is organized in derivational paradigms, in which the edges and labels code the relations of lexical and morphological inheritance that arise in each paradigm. Lexical layers are represented by means of successive generations of children stemming from the parent node, as can be seen in Figure 3.



The representation in Figure 3 also shows that the neuter noun *(ge)bod* ‘message’ is a zero derivative of the strong verb while functioning as base of derivation of *(ge)bodlāc* ‘decree, so that the more productive layer of affixation is defined by the recursive formation on the output of the less productive layer of zero derivation. Last but not least, the information relevant for the concepts in the ontology in Figure 2 can be retrieved by clicking on the item in question. Overall, the representation in Figure 3 codes all the concepts and relations that give rise to the ontology of the derivational map, which are displayed in 3D. However, further steps have to be taken if a three-dimensional concept of the lexicon is pursued, which, moreover, stresses the dynamics of language change. A preliminary design of such three-dimensional lexicon is offered in the next section, which centres on semantic poles.

#### 4. SEMANTIC POLES. TOWARDS A 3D REPRESENTATION OF THE LEXICON

This section offers the blueprint of a three-dimensional representation of the lexicon based on the general concepts of space and dynamism. More specifically, dynamic lexical space is couched in terms of 3D representation, with a view to shedding light on three questions central to semantic analysis and lexical semantics, to wit, the relationship between the morphological and the semantic sides of lexical creation, polysemy and the distribution of lexical items.

Lexical space is dynamic as a result of lexical creation and semantic change, which includes, among other phenomena, lexical specialization and the rise of non-literal meanings. The empirical basis of the proposal is provided by the data available in many languages which evidence that throughout lexical evolution new words are coined or borrowed while additional meanings are conveyed by already existing words, thus giving rise to one of the most widespread linguistic phenomena, to wit, polysemy. This proposal entails that lexical space is a panchronic construct consisting of lexical layers comprised of the successive waves of new lexemes and the expanded or modified meanings that have been incorporated into the lexicon. In other words, the underlying concept of the lexicon is that of shared semantic knowledge in constant evolution which is coded as a set of linguistic traditions ranging from archaisms to neologisms and that correspond to several strategies of lexical expansion, including, at least, borrowing and word-formation<sup>7</sup>.

This proposal has the important consequence of introducing dynamism into the model in an explicit way. In the methodology of classical structuralism, the point of drawing a distinction between the synchronic and the diachronic axis was precisely to isolate a static linguistic stage in which linguistic evolution did not blur the contrasts on which the systematic character of language crucially depends. Evidence against this methodological stance can be gathered in various areas of language. In word-formation, for instance, fully productive processes coexist with relatively unproductive processes and with totally unproductive ones that can only be reconstructed on the grounds of their output. Consequently, a strictly synchronic or diachronic approach to derivational

morphology is likely to overlook many data that, on the other hand, can be accounted for by means of an approach that combines synchronic information and diachronic information relevant for synchronic analysis. Put differently, while productive processes of word-formation are compatible with a static view of the lexicon, the remnants of formerly productive processes require an analysis that focuses on lexical dynamism. If an overall explanation for derivational morphology is sought, this means that derivational morphology cannot be restricted to word-formation rules but has to accommodate lexical redundancy rules and, moreover, link the two sets of rules to each other in a principled way.

Let us illustrate the research questions just posed with Old English data. Consider the paradigm of *(ge)rīsan* (strong I) ‘to rise, raise; seize; rush; be proper’, to which the zero derived *rās* (masculine) ‘rush’ and *rāsan* (weak I) ‘to rush’ belong. Whereas prefixed derivatives of the weak verb convey rather broad and predictable (directional) meanings, as in *onrāsan* (weak I) ‘to rush on’, *berāsan* (weak I) ‘to rush upon’ and *forðrāsan* (weak I) ‘to rush forth’, recursive derivatives display narrower and less predicatable meanings, as is the case with *onrāsend* (masculine) ‘attacker’, a derivative of *onrāsan* ‘to rush on’ (compare the zero derived masculine noun *onrās* ‘onrush’). As in many other instances, the degree of recursivity of the derivation is in direct proportion to the degree of hyponymy of the derivative. It also turns out that polysemy is a characteristic of the hyperonym *(ge)rīsan* (strong I) ‘to rise, raise; seize; rush; be proper’ rather than the hyponym *onrāsend* (masculine) ‘attacker’, for instance.

Regarding the overall organization of the lexicon, some languages, as is the case with Old English, undergo a change whereby a convergent lexicon (in which hyponymy relations are based on word-formation) is replaced by a divergent lexicon (in which hyponymy relations are due not only to word-formation but also to borrowing and the new semantic relations that arise as a result of the new non-literal meanings conveyed by items with a former literal meaning). This can be seen in the paradigm of *(ge)rīsan*: whereas the Old English part is consistently Germanic, the translation relies on some borrowed terms like ‘attacker’.<sup>8</sup>

In the third place, one of the most outstanding aspects of lexical organization is the uneven distribution of lexical items, which tend to cluster around certain lexical areas to the exclusion of others, which contain fewer lexical items. For instance, there are around 150 verbs that convey the meaning ‘to go’ in Old English. Although this does not mean that hyperonyms cannot be identified, thus *faran* (strong VI), *gān* (irregular) and *gangan* (strong VIIId), many other verbs express the meaning ‘to go’ primarily or secondarily, including:

(1)

*būgan* I (strong II), *cierran* (weak I), *dragan* (strong VI), *ferian* (weak I), *geceorran* (weak), *gengan* (weak I), *hæppan* (weak), *healdan* (strong VIIc), *hlēapan* (strong VII), *hwærfan* (weak), *hweorfan* (strong IIIb), *hwierfan* (weak I), *hyrsian* (weak), *innian* (weak), *lēoran* (weak with strong forms), *lecgan* (weak I), *lendan* (weak I), *līðan* (strong I), *licgan*

(strong V), *nēosan* (strong II), *niman* (strong IV), *racian* (weak), *reccan* (strong V), *reccan* (weak 1), *rōwan* (strong VIIIf), *scēon I* (weak), *scrīðan* (strong I), *scūfan* (strong II), *sēcan I* (strong II), *sīðian* (weak 2), *sīgan I* (strong I), *snēowan* (strong II), *snyðian* (weak), *spyrian* (weak 1), *stæppan* (strong VI), *stalian* (weak 2), *sīgan* (strong I), *strīcan* (strong I), *tēon I* (strong II), *wadan* (strong VI), *wealcan* (strong VIIc), *weallian I* (weak), *wendan* (weak 1), *wītan* (strong I), *windan* (strong IIIa), *wrigian* (weak).

While linguistic relativism has traditionally explained this question in terms of cultural idiosyncrasy that favours certain lexical creations but does not implement others, in the remainder of this paper it is hypothesized that a significant part of the lexicon revolves around semantic poles, which stand out as pivotal elements that motivate lexical hierarchies. Such semantic poles can also contribute to the explanation of the other aspects of lexical organization just raised, namely the distribution the degree of convergence of lexical and morphological inheritance and polysemy. With these aims, semantic poles are defined dynamically, as entities of lexical space exerting centrifugal forces directed away from the pole and centripetal forces exerted towards the pole.<sup>9</sup>

The search for such semantic poles requires a double perspective of analysis. In this proposal, the more semantically oriented part of the question is tentatively addressed in terms of semantic primes while the more morphologically side is dealt with on the grounds of derivational paradigms as discussed in Section 3. As for semantic primes, the Universal Semantic Metalanguage Research Programme (Goddard 2002; Wierzbicka 2002; Goddard and Wierzbicka 2002) has compiled a list of of semantic universals of linguistic organization with deep-rooted pragmatic and cultural motivation that have exponents in all natural languages.<sup>10</sup> In the latest formulation, the inventory of semantic primes includes: Substantives (I, YOU, SOMEONE, PEOPLE, SOMETHING/THING, BODY), Determiners (THIS, THE SAME, OTHER), Quantifiers (ONE, TWO, SOME, ALL, MUCH/MANY), Evaluators (GOOD, BAD), Descriptors (BIG, SMALL), Mental predicates (THINK, KNOW, WANT, FEEL, SEE, HEAR), Speech (SAY, WORDS, TRUE), Actions, events and movement (DO, HAPPEN, MOVE), Existence and possession (THERE IS, HAVE), Life and death (LIVE, DIE), Time (WHEN/TIME, NOW, BEFORE, AFTER, A LONG TIME, A SHORT TIME, FOR SOME TIME), Space (WHERE/PLACE, HERE, ABOVE, BELOW, FAR, NEAR, SIDE, INSIDE), Logical concepts (NOT, MAY BE, CAN, BECAUSE, IF), Intensifier, augmentor (VERY, MORE), Taxonomy, partonomy (KIND OF, PART OF) and Similarity (LIKE). The discussion that follows focuses on the Speech prime TRUE.

In Old English, the exponents of the semantic prime TRUE include the adjectives *trēow* ‘true’ and *sōð* ‘true’, whose derivational paradigms can be seen in (2a) and (2b) respectively:

(2)

a. *Fortrūwian* ‘to be presumptuous’, *fortrūwodnes* ‘presumption’, *fortrūwung* ‘presumption’, *fultrūwian* ‘to confide in’, *(ge)trēowð* ‘truth’, *(ge)trēowan* ‘to believe’, *(ge)trēowfæst* ‘true, faithful’, *(ge)trēowful* ‘faithful, trusty, true’, *(ge)trēowfullīce*

‘faithfully’, *(ge)trēowlēas* ‘faithless, treacherous, false; unbelieving’, *(ge)trēowsian* ‘to plight one’s faith; exculpate oneself’, *(ge)trūwa* ‘fidelity, faith, confidence, trust, belief; pledge, promise, agreement, covenant; protection’, *(ge)trūwian* ‘to trust’, *getrēowfæstnian* ‘to be trusty’, *getrēowlēasnes* ‘treachery, faithlessness; unbelief, heresy’, *getrēownes* ‘faithfulness’, *getrūwung* ‘confidence’, *hēahtrēow* ‘solemn compact’, *hygetrēow* ‘fidelity’, *ofertrūwa* ‘over-confidence’, *ofertrūwian* ‘to trust too much’, *ontrēowan* ‘to entrust’, *ortrēownes* ‘mistrust’, *ortrūwian* ‘to doubt’, *ortrūwung* ‘doubt’, *trēow* ‘truth, fidelity, faith, trust, belief; pledge, promise, agreement, treaty; favour, grace, kindness’, *trēowdrāg* ‘time for faithfulness’, *trēowe* ‘true, faithful, honest, trustworthy; genuine’, *trēowgedofta* ‘faithful comrade’, *trēowlīce* ‘confidently’, *trēowlic* ‘true, faithful, trusty; safe’, *trēowloga* ‘pledge-breaker’, *trēowlufu* ‘true love’, *trēowrāden* ‘state of fidelity’, *ungetrēowd* ‘unfaithfulness, treachery’, *ungetrēowe* ‘untrue, faithless’, *ungetrēownes* ‘unbelief; faithlessness’, *untrēowd* ‘unfaithfulness, treachery’, *untrēowe* ‘untrue, unfaithful’, *untrēowfæst* ‘unfaithful, unreliable’, *untrēowlīce* ‘faithlessly’, *untrēownes* ‘unfaithfulness’, *untrēowsian* ‘to defraud, deceive; offend’, *winetrēow* ‘conjugal fidelity’.

b. *Folcsōð* ‘simple truth’, *sōð* ‘truth’, *sōð* ‘true’, *sōðbora* ‘soothsayer’, *sōðcwed* ‘veracious’, *sōðcweden* ‘veracious’, *sōðcwide* ‘truth’, *sōðe* ‘truly’, *sōðfæst* ‘true’, *sōðfæstian* ‘to justify’, *sōðfæstlic* ‘true’, *sōðfæstnes* ‘truth’, *sōðian* ‘to prove true’, *sōðlic* ‘true’, *sōðsagol* ‘truthful’, *sōðsecgan* ‘to speak the truth’, *sōðspāce* ‘truthful’, *tōsōðan* ‘in truth’.

By considering the evidence gathered in (2), two distinctions are made that might be added to the methodology of semantic primes. The first distinguishes major from minor exponents of a prime. Major exponents convey as the only or main meaning the meaning coded by the semantic prime, whereas minor exponents convey the meaning of the prime only secondarily. The minor exponents of the semantic prime TRUE include *tāwe*, *clāne*, *efen*, *eornost*, *forðcuman*, *hold*, *riht* and *wār*. Other exponents given by (2), such as *logen*, *lēas*, *lygen*, *māne*, *swicende*, *swicol*, represent inverse exponents. Unlike direct exponents of the type *trēow* ‘truth’, inverse exponents convey a meaning that results from the combination of lexical negation with an opposite term (*truth-lie*, *tell the truth-lie*, etc.). This is the case with the derivatives of the verbs *lēogan* ‘lie’ and *swīcan* ‘deceive’ as well as the adjectives *lēas* ‘false’ and *māne* ‘criminal’. Apart from the distinctions drawn above, two remarkable aspects arise from the discussion of (2). The first is the generalized character of polysemy, which has to be incorporated into lexical description and explanation. The proposal advanced above allows for the inclusion of polysemy through the difference made between major and minor exponents of semantic primes. Moreover, polysemy is not contrained by morphological inheritance once the distinction between direct and inverse exponents has been made. On the methodological side, the concept of direct and inverse exponent is necessary because a semantic prime like UNTRUE has not been put forward (neither is the logical concept NOT directly applicable), and, consequently, it is not possible to describe a relation of antonymy *true-untrue* but rather one of inverse exponence of the semantic prime in question, namely *true-*



*unfalse*. The second aspect that deserves comment is the importance attributed to lexical creation as a criterion for identifying semantic primes. That is, lexical impact is a factor for identifying the exponents of a semantic prime, around which a significant number of derivatives revolve that also convey the meaning associated with the semantic prime. This is in accordance with lexical creation as a central explanatory concept of lexical organization and with lexical derivation as a means of relating direct to inverse exponents of a semantic prime through relations of polysemy.

In a 3D lexicon based on the concept of dynamic lexical space, semantic poles are areas of convergence of lexical primes and semantic primes. Therefore, a semantic pole is not restricted to a single lexeme or metapredicate. Rather, a semantic pole is the area of lexical space defined as the intersection of the lexical areas of derivational paradigms and the major exponents of semantic primes. Figure 5 represents the semantic pole *sōð-trēowe* in Old English. Notice that a strong formulation of a non-synonymy principle is adopted because the lexical areas of *sōð* and *trēowe* do not overlap, while both intersect with the area of TRUE, given that many exponents of this semantic prime constitute derivatives of the paradigms of *sōð* or *trēowe*.

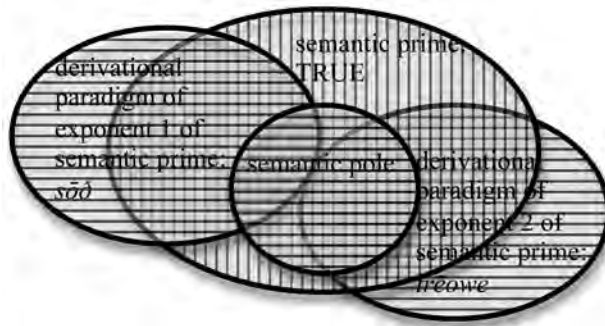


Figure 5. *The semantic pole sōð-trēowe in Old English.*

Semantic poles attract lexical items to the meaning of the pole in question. This explains three facts of lexical organization. Firstly, what may be called *incremental polysemy*, which reflects the fact that the more polysemic a lexical item is, the more likely it is to develop new senses or meanings, the opposite also holding. Secondly, there is meaning continuity among lexical areas. And, thirdly, the overall organization of the lexicon represents the balance resulting from the simultaneous operation of two kinds of forces: a centripetal force towards the meaning of a given semantic pole and a centrifugal force away from the semantic pole in question (and towards other semantic poles). Consider, as illustration, the effect on other lexical areas of the centripetal force towards the semantic pole *sōð-trēowe*:

(3)

*Æltæwe* ‘complete, entire, perfect, healthy, sound, **true**’, *clæne* ‘clean; pure, chaste, innocent; unencumbered, unfettered; hallowed; clear, open; honourable, **true**; acute, sagacious, intellectual’, *efen* ‘even, equal, like, level; just, **true**; calm, harmonious, equable’, *eornostlice* ‘earnestly, strictly, **truly**, in truth, indeed’, *forðcuman* ‘to come forth, proceed, arrive at, succeed; come to pass, come **true**; be born’, *hold* ‘gracious, friendly, kind, favourable; true, faithful, loyal; devout; acceptable, pleasant’, *riht* ‘straight, erect, direct; right, proper, fair, just, equitable, lawful, permissible; upright, righteous; **true**, correct; fitting, appropriate; real, genuine; right’.

Figure 6 represents some effects of the centripetal force towards the semantic pole *sōð-trēowe*.

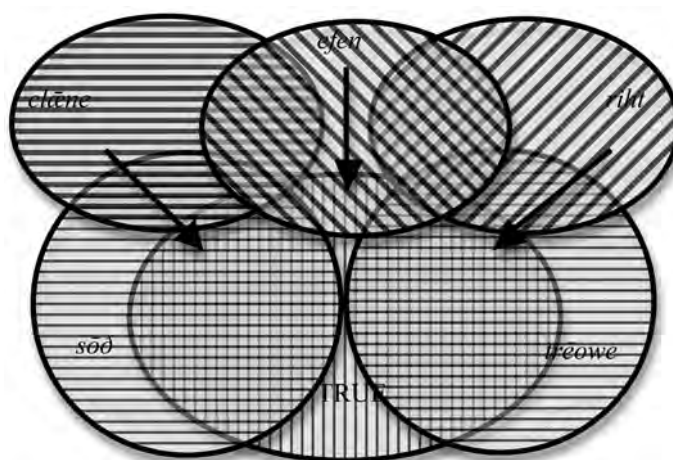


Figure 6. *Centripetal force towards the semantic pole.*

Conversely, the lexical items in (4) undergo centrifugal force from the semantic pole *sōð-trēowe*:

(4)

*Sōð* ‘truth, **justice, righteousness, rectitude; reality, certainty**’, *sōð* ‘true, genuine, real; just, righteous’, *sōðfæst* ‘true, **trustworthy, honest; just, righteous**’, *sōðfæstnes* ‘truth, truthfulness, **fairness, fidelity; justice**’

It must be noted that the lexical items listed in (4) are very polysemic, as the principle of incremental polysemy predicts, and, moreover, do not constitute mayor exponents of any semantic prime. Although more research is needed in this area, it seems that universal semantic categories (semantic primes) overrule language-specific

lexical organization (derivational paradigms). It is also worth remarking that the adjectives *clāne*, *efen* and *riht* enjoy the status of bases of their respective derivational paradigms. In this respect, semantic attraction of the centrifugal type towards a semantic pole can explain the typically hyperonymic character of the bases of derivational paradigms. Figure 7 presents centrifugal force away from the semantic pole:

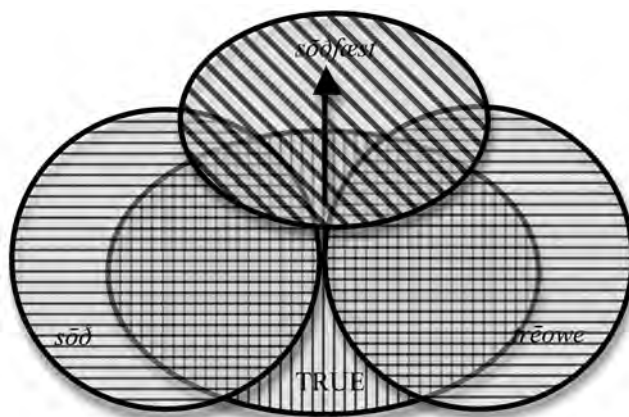


Figure 7. *Centrifugal force away from the semantic pole.*

Semantic poles thus defined account for the uneven distribution of lexical items whatever the criterion of classification selected. In other words, regardless of the fact that lexemes are grouped on the grounds of semantic fields, sets of exponents of semantic primes or derivational paradigms, the number of members of each class differs considerably from other classes. The thrust of this proposal, however, is that dynamism constitutes not only a product of linguistic evolution but also an explanatory principle that accounts for the clustering of lexical items around certain semantic poles and predicts the rise of polysemy. Thus, centripetal semantic forces attract meanings towards pivotal areas of the lexicon or semantic poles, whereas centrifugal semantic forces repel meanings thus separating them from the meaning conveyed by the semantic pole. Centripetal semantic forces defined in this way can explain the rise of polysemy, which is less likely to turn up in derived than in basic lexemes. At the same time, relations of derivation are often paralleled by relations of hyponymy, so that the more derived and/or recursive the more hyponymic non-basic lexemes are. Put differently, a dynamic proposal for lexical space such as the one advanced here assesses the different degrees of convergence between word-formation and hyponymy that the lexicon of a given language can throw while providing an explanation for the phenomenon of polysemy.

## 5. CONCLUSION

This article has described the design and compilation of a lexical database of Old English that has been used to draw a full derivational map of this stage of the English language. The derivational map has been represented in 3D and, with the aim of contributing to three-dimensional linguistic representation as well as to third-generation Internet, significant steps have been taken to construe dynamic lexical space. The most relevant conclusions of the undertaking can be summarized as follows.

The concept of derivational paradigm, which stresses the convergence of morphological and semantic inheritance in meaning construction, has been applied to the lexicon of Old English. Such application has the descriptive advantage of exhaustivity and, on the side of explanation, integrates synchronic data and diachronic data relevant for synchronic analysis. Moreover, the derivational paradigm, with its stepwise decomposition of lexical derivation, provides the basis of the graph analysis of the lexicon, which, in turn, opens new research avenues in the 3D linguistic representation of the lexical stock.

The concept of semantic pole, as applied to a lexical database especially designed for three-dimensional representation, not only constitutes an explanatory principle of derivational morphology and lexical semantics but also contributes to the development of the third-generation Internet, which is, among other things, geared to the compilation of databases and the 3D representation of web contents. Hypertext links, characteristic of *www1*, are kept but do not constitute the stronghold of the model. Rather than relying on hypertext links that specify bilateral relations in one plane, or in two dimensions, this three-dimensional model represents lexical space as comprised of constellations of semantic poles that attract and repel features or components of meaning, in such a way that multilateral relations can hold on a given plane or across planes.

In linguistic analysis, the area of contact between morphology and lexical semantics is conceived of as an architectural scheme defined by the intersection of the panchronic axis and semantic organization. On the panchronic axis, lexical primes around which derivational paradigms revolve, motivate not only word-formation but, furthermore, lexical organization. The morphological side of lexical representation is not restricted to derivational (motivated by form and content) and semantic (motivated by content) relations. Instead, lexical and semantic networks give rise to a three-dimensional structure governed by a dynamic concept of lexical space that integrates several lexical layers consisting of lexical items and morphological processes of lexical creation. On the semantic side, semantic primes as defined by the Semantic Metalanguage Research Programme constitute a promising starting point in the search for the nuclear semantic concepts on which the lexical stock centres, but further research is necessary to compile the full inventory of poles, which, moreover, calls for more language-specific work. In this respect, the concepts and theoretical constructs reviewed or developed in this article, including the lexical paradigm and derivational map as well as inheritance relations represented by means of graph theory, are applicable to the

lexical stock of any language. As for 3D representation, a dynamic lexicon based on a derivational map can be generated for any language by means of the procedure described above if a lexical database like the one developed for Old English is provided.

## NOTES

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1. This research has been funded through the projects FFI08-04448/FILO (*Nerthusv2: Base de datos léxica en 3D del inglés antiguo*) and FFI2011-29532 (*Polos semánticos en el léxico del inglés antiguo. Construcción del significado, primitivos semánticos y formación de palabras*).
  2. See Ellis (1993) for more information on Old English dictionary entries and the problem of spelling.
  3. The initial headword list has been published by the *Woruldhord Project* (Oxford University Press) and is available at <http://poppy.nsms.ox.ac.uk/woruldhord/contributions/595>.
  4. The PLPG draws on Mairal Usón and Cortés Rodríguez (200-2001) and Cortés Rodríguez and Sosa Acevedo (fc.), who stress the central role played by lexical derivations in grammatical projection and linking. The ontological approach to lexicology adopted by these authors has also been a source of inspiration for this research.
  5. For further information on causative formations in Germanic and Old English, see García García (2005, fc.-a, fc.-b).
  6. Homophonic ambiguity is an infrequent phenomenon in Old English. When it turns up, it is also dealt with by means of numbered predicates, as, for instance, in *l̥oht* 1 'light' (adjective) and *l̥oht* 2 'light' (noun). See also Caballero González *et al.* (2004-2005), Torre Alonso *et al.* (2008) and Martín Arista (2010, fc.).
  7. See Kastovsky (fc.) on the role of loans translation in Old English word-formation.
  8. Kastovsky (1989, 1990, 2006) deals with the evolution of English morphology and draws the conclusion that a typological change has taken place as a result of which stem-based morphology was replaced by word-based morphology by the end of the Old English period. This author (1992: 294) describes the lexicon of Old English as *associative* (that is, mainly Germanic and based on morphological relations) and the one of Present-day English as *dissociated* (that is, mixed Romance-Germanic with looser morphological links). Although the questions raised here exceed the scope of Kastovsky's work, the contribution made by this linguist to the study of the Old English lexicon has represented an invaluable starting point for this project.
  9. Talmy (2000: 467) has proposed four schematic systems that organize the speech-event scene: configurational structure (temporal and spatial location of a scene by means of certain sentence elements), location of perspective time (location or direction of the vantage point), distribution of attention (foregrounded vs. backgrounded elements) and force dynamics (the forces exerted on each other by the elements of the structural framework). Although the schematic system of force dynamics allows to interpret grammatical categories in terms of exertion of force, resistance to such a force, overcoming of resistance, blockage of force, removal of blockage, etc., Talmy (2000: 428) regards it as a generalization over "causative", thus avoiding questions like the ones raised in this research.
  10. Some exponents of semantic primes have been found in Old English by Martín Arista (2005), Martín Arista and Martín de la Rosa (2006), de la Cruz Cabanillas (2007) and Guarddon Anelo (2009a, 2009b).

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