Combining Neo-Structuralist and Cognitive Approaches to Semantics to Build Wordnets for Ancient Languages: Challenges and Perspectives

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Abstract

This paper addresses challenges encountered in constructing lexical databases, specifically WordNets, for three ancient Indo-European languages: Ancient Greek, Latin, and Sanskrit. The difficulties partly arise from adapting concepts and methodologies designed for modern languages to the construction of lexical resources for ancient ones. A further significant challenge arises from the goal of creating WordNets that not only adhere to a neo-structuralist relational view of meaning but also integrate Cognitive Semantics notions, aiming for a more realistic representation of meaning. This integration is crucial for facilitating studies in diachronic semantics and lexicology, and representing meaning in such a nuanced manner becomes paramount when constructing language resources for theoretical research, rather than for applied tasks, as is the case with lexical resources for ancient languages. The paper delves into these challenges through a case study focused on the TEMPERATURE conceptual domain in the three languages. It outlines difficulties in distinguishing prototypical and non-prototypical senses, literal and non-literal ones, and, within non-literal meanings, between metaphorical and metonymic ones. Solutions adopted to address these challenges are presented, highlighting the necessity of achieving maximum granularity in meaning representation while maintaining a sustainable workflow for annotators.

Keywords: WordNet, ancient Indo-European languages, relational semantics, cognitive semantics, temperature domain

1. Introduction

In this paper, we delve into some challenges encountered while building three lexical databases, specifically WordNets, for three ancient Indo-European languages: Ancient Greek, Latin, and Sanskrit (Biagetti et al. 2021). These issues are partly related to adapting a set of concepts and methodologies designed for modern languages to constructing lexical resources for ancient ones, thus without relying on native speakers' support.

Crucially, another set of challenges stems from our programmatic goal of constructing WordNets that not only adhere to a neo-structuralist relational view of meaning (Geeraerts, 2010: 124-126, 158-160) but also integrate notions of Cognitive Semantics (e.g., Taylor, 2003; Aitchinson, 2003). This integration should allow for a more fine-grained and "more realistic" representation of meaning (Geeraerts, 2001: 18-19; 2007: 1168), thus facilitating studies in diachronic semantics and lexicology. In principle, a representation of meaning of this sort is of primary importance when constructing language resources that are not primarily aimed at applied tasks but rather at theoretical research, as are lexical resources of ancient languages. The paper discusses the latter set of issues through the lens of a case study, specifically examining the meanings associated with words pertaining to the TEMPERATURE conceptual domain in the three languages[1].

The paper is organized as follows. In Section 2 we present the new family of WordNets for ancient Indo-European languages. Specifically, in Section 2.1 we introduce the main features of WordNets, specifying the types of semantic information they contain and those they do not. In Section 2.2 we explain how we enhanced our WordNets with notions of Cognitive Semantics and present the potential of this approach. Section 3 contains a discussion of the challenges encountered in such implementation, taking the lexicon of TEMPERATURE as a case study. In particular, we outline the difficulties faced in distinguishing between prototypical and non-prototypical senses, literal and non-literal ones, and – among non-literal senses – between metaphorical and metonymic ones. We also present the solutions adopted to address these challenges. Section 4 contains the conclusions.

2. A family of WordNets of Ancient Indo-European Languages

2.1 WordNets: What Semantic Information They Contain, What They Do Not

WordNet is a lexical database that stores meaning in a network, initially designed by the psycholinguists George Miller and Christiane Fellbaum (Fellbaum, 1998; Miller and Fellbaum, 2007; Miller et al., 1990) and compiled for English at Princeton University. However, it soon lost its psycholinguistic flair and became a project in computational lexical semantics. Since the first Princeton WordNet, similar databases have been built (e.g., Vossen 1998, 2004) or are currently being built for many other languages, including ancient ones such as Latin, Ancient Greek, Sanskrit, and Old English. Researchers have further attempted to link these WordNets to larger language resource infrastructures (Biagetti et al. 2021; Khan et al., 2023; for Latin, see Bizzoni et al., 2014; Minozzi, 2017; Franzini et al., 2019; Mambrini et al., 2021; for Ancient Greek, see Boschetti, 2019; Zanchi et al., 2021; for Sanskrit, see Hellwig, 2017; Old English: Khan et al., 2022). Nowadays, the Global WordNet Association (available at http://globalwordnet.org/) promotes a collective forum for the standardization of existing WordNets, as well as for the development of shared guidelines and methodologies for building new WordNets and related linguistic resources.

[1] In Cognitive Semantic scholarship, concepts, conceptual domains and conceptual metaphors are conventionally noted with caps lock. In this paper we adhere to these conventions.

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The fundamental bricks of WordNet architecture are represented by synsets, which can be defined as unordered sets of near-synonymic lemmas accompanied by a gloss and identified by an ID-number. Currently, the Princeton WordNet has reached version 3.1. Over time, new WordNet releases have included sets of synsets with varying IDs (for more information on the stability of these IDs over time, refer to Kafe, 2017). Synsets group together WordNet nodes, representing open-class parts of speech (lemmas) of a given language, specifically, nouns, verbs, adjectives, and adverbs. WordNet design makes use of a shallow notion of synonymy (Miller et al., 1990: 241): synsets collect synonymous word *readings* or *senses* and not "absolute synonyms", that is, words that can replace one another in all conceivable contexts (Murphy, 2010).

For example, in the current version of the Princeton WordNet, the synset "n#05022301 | the absence of heat" includes the nouns "cold", "coldness", "low temperature", "frigidity", and "frigidness". Lemmas can belong to multiple synsets, which is how WordNets represent polysemy: for example, in the Princeton WordNet, "cold" as a noun is also included in the following synsets:

- n#05733621 | the sensation produced by low temperatures
- n#14168983 | a mild viral infection involving the nose and respiratory passages (but not the lungs)

WordNets' nodes, or lemmas, are linked via lexical-morphological relations, while specific senses of lemmas, grouped in synsets, are connected through conceptual-semantic relations (for the complete set of relations in the Princeton WordNet, see Fellbaum, 1998).

Synsets, in turn, are grouped into semantic fields called 'semfields': for example, the above synsets "n#14168983 | a mild viral infection involving the nose and respiratory passages (but not the lungs)" and "n#05733621 | the sensation produced by low temperatures" belong with the semfield {Medicine and Health}, whereas the synset "n#05022301 | the absence of heat" pertains to the semfield {Physics}.

What we have discussed so far shows that, in WordNets, lexical meaning is understood as arising from relations among word senses and is accordingly stored in a relational manner. This is precisely why Geeraerts (2010) includes the WordNet project and its strands among neo-structuralist approaches to semantics, particularly among elaborations of structuralist relational semantics.

Structuralist relational semantics, best represented by Lyons' (1963), Cruse's (1986), and Murphy's (2003) seminal works, aimed to identify a theoretical apparatus and vocabulary to describe the structural relations among related words, such as synonymy, antonymy, hyponymy, hyperonymy, and meronymy, independently from encyclopedic knowledge and excluding cause-effect relations (e.g., the relation holding between *music* and *composer*). In fact, WordNets, too, fail to account for relations between concepts that are particularly close from a thematic, functional or encyclopedic point of view – a shortcoming often referred to as the 'tennis problem' (Fellbaum, 1998; Sampson, 2000). To use the tennis example, WordNets typically do not contain any coded information regarding the fact that "tennis", "ball", "racquet", and "net" are related concepts. From a taxonomic and somewhat inverse perspective, this issue is known as "IS-A overload" (Guarino, 1998; Guarino and Welty, 2002; Huang et al., 2008), a situation where semantically heterogeneous words are grouped as co-hyponyms (X is a Y) under the same hypernym. For example, the word "mask" in Princeton WordNet belongs to the synset "n#03730526 | a protective covering worn over the face" and has the following hyponyms "face mask" (for sports), "gas mask", "respirator", "gas helmet", and "welder's mask". These co-hyponyms may share the very general functionality of covering and protecting the face but are used in very different situations and belong to very different domains of reality. In cognitive semantic terms, WordNets do not capture frames (see Section 2.2).

2.2 Enhanced WordNets for Ancient Indo-European Languages

Cognitive Semantics emerged in the 1980s stemming from Cognitive Linguistics (e.g., Lakoff and Johnson, 1980; Lakoff, 1987; Taylor, 2003; Aitchinson, 2003; classic introductions in Cognitive Linguistics include Croft and Cruse, 2004; Ungerer and Schmidt, 2006; see also the scholarship overview in Geeraerts 2010: 267-272). Cognitive Linguistics looks at language in the larger context of cognition and regards language use as the essential methodological basis of linguistics. More specifically, on meaning, the three leading ideas of Cognitive Semantics can be summarized as follows:

i. Meaning exceeds the boundaries of the word and is part of larger conceptual structures, called 'frames' (Fillmore, 1975; 1985) or 'idealized cognitive models' (Lakoff, 1987), which are evoked by specific words or expressions.
ii. Meaning is contextual and pragmatically flexible, which led Cognitive Semantics to developing the idea that polysemy is structured and can be organized around a prototypical meaning (e.g., Lakoff, 1987; Brugmann, 1988; see the overview in Mangasser-Wahl, 2000) and to becoming interested in studying how actual language use drives semantic change.
iii. Expressing meaning entails perspectivization, in that complex sets of concepts, or domains, can be referred to using simpler ones, via cognitive metaphor and metonymy (Lakoff and Johnson, 1980; Kövecses, 2002; see also the handbook on metaphor theory by Gibbs, 2008).

The advantages of incorporating Cognitive Semantics into traditional lexicographic practice has been highlighted, for example, by Ostermann (2015: 48-49; earlier also by Geeraerts, 2001: 19 and by Langacker,

2005: 342), and are related to building dictionaries whose structure more closely resembles that of the mental lexicon, while simultaneously addressing the so-called 'linearization problem'. In Geeraert's (2001: 18) words, this problem describes "the fact that lexicographers [...] have to project a multidimensional clustered semantic structure onto the linear order of a dictionary". As discussed in Section 2.1, traditional WordNets clearly overcome the linearization problem, as they consist of networks of nodes linked by paradigmatic relations. However, WordNets do not store frame relations, a shortcoming that has been acknowledged as early as in Fellbaum (1998) and to which computational lexicographers still strive to find a solution (cf. Fellbaum, 2010; Koeva, 2020).

In fact, the cognitive linguistic notion of frame was extensively applied to corpus-based lexical analysis within the FrameNet project (Fillmore and Atkins, 1992; Atkins et al., 2003b; Fillmore et al., 2003, Fillmore and Petruck, 2003), whose aim is building a human- and machine- readable lexical database for English accounting for how words are used in context and how words fit into larger conceptual structures (see also https://framenet.icsi.berkeley.edu/about). Later, especially in the first decade of the 2000s, computational linguists and lexicographers attempted various computational approaches to automatically integrate WordNet and FrameNet (see, among others, Shi and Mihalcea, 2005; Tonelli and Pighin, 2009; Laparra & Rigau 2010).

Note that both WordNets' neostructuralist approach and Cognitive Semantics can be regarded as onomasiological in nature: they are both interested in looking at sets of lexical items simultaneously rather than at single lexical items. WordNet does so by clustering word senses in semantic fields ('semfields'; cf. Section 2.1), Cognitive Semantics by grouping them in frames. However, Fillmore and Atkins (1992: 76-77) well highlight the fundamental difference between these two approaches: (neo)structuralists link words, or better, word senses, directly to one another, whereas for Cognitive Semantics such relations are mediated by frames, which are made up based on our structured experience, beliefs, and practices.

In our family of WordNets of ancient languages, semantic frames are not currently annotated: thus, we have not yet incorporated in our computational lexica the first leading idea of Cognitive Semantics introduced above. This is due to the unavailability of FrameNet-like lexical databases for Latin, Ancient Greek, and Sanskrit. However, we did attempt to enhance, by adding *syntactic* frames, the verbal lemmas contained in the Ancient Greek and Sanskrit WordNets (Zanchi et al. 2021; Biagetti et al. 2023a; Biagetti et al. 2023b) and syntactic frames are being systematically annotated in the Latin WordNet in the framework of the LiLa project since earlier times (Mambrini et al. 2021).

On the other hand, in our family of WordNets we did integrate the latter two leading ideas of Cognitive Semantics presented above. First of all, to account for the contextual and pragmatical flexibility of meaning (see Section 2.2., point ii), we tag each lemma sense, that is, each synset to which each lemma belongs, for periodization, literary genre(s), and loci of attestation. For example, the Ancient Greek adjective *thermós* 'hot' is attributed to 12 synsets in the Ancient Greek WordNet. For each synset, the above pieces of information are specified as shown in the examples in (1):

(1) Lemma: *thermós*
  a. Synset: a#02407344 | having or producing a comfortable and agreeable degree of heat or imparting or maintaining heat: "a warm body"
    i. Periodization: Archaic (8th c. - 6th c. BCE); Classical (5th c. - 323 BCE); Hellenistic (323-31 BCE); Roman (31 BCE-290 CE)
    ii. Genre: Poetry, epic; Theater, comedy; Theater, tragedy; Philosophy, dialogue
    iii. Loci: Hom.*Il*.22.244; E.*Rh*.790
  b. Synset: a#01127729 | resulting from inflammation
    i. Periodization: Classical (5th c. - 323 BCE)
    ii. Genre: Theater, comedy; Theater, tragedy
    iii. Loci: S.*Ph*.696

This information makes our WordNets suitable for studies in diachronic lexicology and onomasiological variation, also in a comparative fashion (see also below about etymology). In other words, our WordNets make it possible to answer research questions such as how word meanings change over time and vary across literary genres and authors.

Moreover, each synset is tagged as literal, metonymic, or metaphoric (Figure 1), and the synset representing the prototypical meaning is identified.

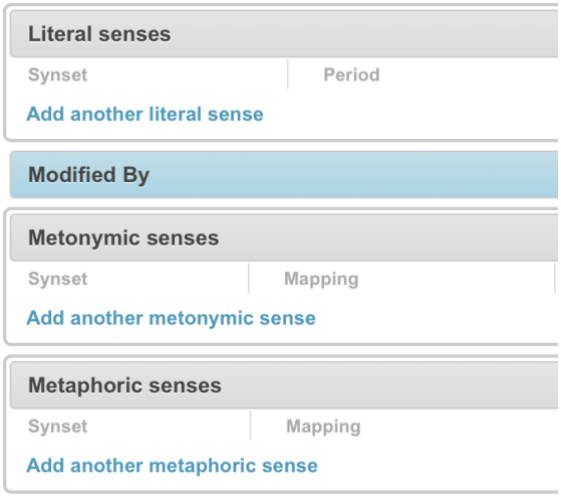

Figure 1: Fields for literal, metonymic and metaphoric senses in the annotation interface.

This type of annotation incorporates the notions of prototype and structured polysemy in our WordNets. Examples are provided in (2):

(2) Lemma: *thermós*
   a. Prototypical synset: a#02407344 | having or producing a comfortable and agreeable degree of heat or imparting or maintaining heat: “a warm body” (cf. (1)a)
   b. Literal synset: a#01195771 | used of physical heat
   c. Metaphorical synset: a#01015627 | freshly made or left: “a warm trail”

Our WordNets also contain etymological information regarding each lemma. For example, for the lemma *thermós*, the recorded Proto-Indo-European root is **g^{hw}er-*, to which two senses are associated, that is, the synsets in (2)a “a#02407344 | having or producing a comfortable and agreeable degree of heat or imparting or maintaining heat” and in (2)b “a#01195771 | used of physical heat”. In our WordNets, etymological information consists of the etymology proper, and optionally of an etymon, i.e., a discrete form in the history of a word’s etymological development, and one or more morphemes, i.e., discrete elements within the etymon (cf. Figure 2).

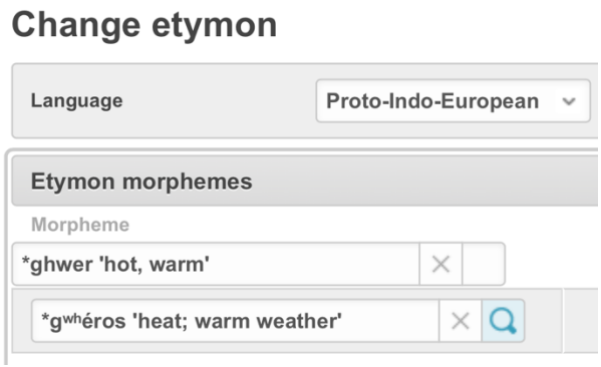

Figure 2: Morpheme and etymon annotation of PIE *g^{wh}éros* ‘heat; warm weather’.

In addition, our databases allow for annotating cognitive metaphors as mappings between synsets. For example, the metaphorical synset in (2)c shows that the adjective *thermós* can trigger the metaphor RECENT IS WARM. In the database, one may keep track of this metaphorical usage by linking the prototypical synset of *thermós* “a#02407344 | having or producing a comfortable and agreeable degree of heat or imparting or maintaining heat” and the metaphorical one “a#01015627 | freshly made or left”. Importantly, this relation of mapping is stored in a section of the database different from that in which traditional WordNet semantic-conceptual relations are stored. In the long run, the final goal would be to build a structured repository of conceptual metaphors (cf. MetaNet available at https://metaphor.icsi.berkeley.edu/pub/en/index.php/MetaNet_Metaphor_Wiki) for ancient Indo-European languages, as it has been partially done for Latin (Fedriani et al., 2020).

Now, before moving on to discuss the reasons why such rich annotation turned out to be problematic, which is the topic of Section 3, it is worth noting that the notion of prototype was not entirely foreign to the Princeton WordNet itself, though it was applied to a totally different part of the database. As documented in Fellbaum (1998), the Princeton WordNet deals with antonymy at a lexical level, not at a synset level. This means that, for example, it is the words “hot” and “cold” that are related by the antonymy relation rather than their corresponding synsets. In the Princeton WordNet, this way of understanding antonymy is implemented by grouping words with similar meanings in clusters (e.g., “cold,” “algid,” “chilly,” “shivery,” “frosty,” etc.), by organizing these clusters around a prototype (“cold”), and by directly linking two antonymous prototypes, while all the other members of the cluster are tagged as indirect antonyms (Figure 3). As shown in Biagetti et al. 2021, this procedure was impossible to follow for ancient languages. Thus, in our WordNets antonymy is treated at the synset level instead, apart from cases in which antonyms are morphologically derived from one another (cf. Sanskrit *uṣṇa-* ‘hot’ and *an-uṣṇa-* ‘not hot, cold’).

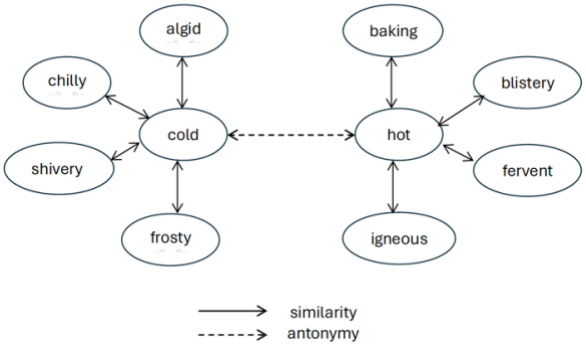

Figure 3: Bipolar Adjective Structure (adapted from Miller et al., 1993: 29).

3. A Case Study: the TEMPERATURE Domain

3.1 The Linguistics of Temperature

The linguistics of temperature is the study of how temperature concepts – e.g., HOT, COLD, LUKEWARM – are conceptualized, that is, organized in speakers’ mind and expressed in world’s languages (Koptjevskaja-Tamm, 2015: 1-40). It also explores the system of temperature terms, considering them as access points to the understanding of temperature concepts. Temperature concepts are interesting for Cognitive Semantics primarily because temperature is an invisible measure experienced by humans through their bodies and expressed through language. Consequently, temperature establishes a connection between natural phenomena, human bodies, and cognitive processes. Additionally, the perception of temperature can vary significantly, with both heat and coldness capable of being either positive or negative experiences for individuals.

The domain of TEMPERATURE is frequently employed to conceptualize more complex cognitive domains, such as the one of emotions via conceptual metaphors. For instance, AFFECTION IS WARMTH (Lakoff and Johnson, 1999: 50) and ANGER IS HEAT (Goossens, 1998; Kövecses, 2002) are two very common metaphors mapping the domain of EMOTIONS onto the one of TEMPERATURE (see also the metaphor RECENT IS WARM in example

(2)c). Being subject to the cognitive processes of metaphor and metonymy, temperature terms are therefore often highly polysemous. Thus, they constitute a good case study to present the potential and drawbacks of an annotation scheme designed to incorporate notions from Cognitive Semantics, such as the notion of structured polysemy and the distinction between literal and non-literal senses, into WordNet architecture.

3.2 Prototypical vs. secondary senses

One of the basic ideas of Cognitive Semantics is that lexical categories and polysemy networks can be thought of in terms of being structured with respect to prototypical meanings (Lakoff, 1987; Langacker, 1987: 376; see also Section 2.2). In this view, the distinct meanings or senses associated with a particular word are related in a principled way to a prototypical or sanctioning sense. According to Tyler and Evans (2003: 45-50; see also Evans, 2004: 96-98), prototypical senses are detected based on the following criteria:

i. early attestation,
ii. concreteness,
iii. predominance in the semantic network.

Importantly for our purposes, these criteria allow for detecting prototypical senses without relying on native speaker intuition.
As already mentioned in Section 2.2, in our annotation scheme, we have initially included the possibility to tag a word sense as prototypical and to distinguish it from its other literal and non-literal senses. However, the distinction between prototypical and secondary senses revealed problematic in many cases. A first problem arises if, for "early attestation," that is, Tyler and Evans' (2003) criterion i), we understand the sense reconstructed for the Proto-Indo-European root associated with the lemma-node in question. In fact, as we have seen for **g^{hw}er-* above, the etymology of a lemma can have more than one sense, which would make the choice of one prototypical sense arbitrary. Even if we interpret the criterion of early attestation as referring to the oldest attested sense in the language under scrutiny, the distinction is problematic. Take, for example, the Ancient Greek noun *págos*. For this noun, the Liddell-Scott-Jones dictionary (i.e., the reference dictionary of Ancient Greek) provides the following definition:

(3) *that which is fixed or firmly set*:
i. crag, rock, generally rocky hill (often used in conjunction with Arēs to mean the Areopagus at Athens)
ii. after Homer = *pagetós*, frost

Chantraine's *Dictionnaire étymologique de la langue grecque* includes *págos* among the derivatives of the verb *pḗgnumi* 'make fast' and attributes to it the meaning 'that which is fixed, hard'. From this derives the meaning 'rock, cliff', attested in older sources and retained in Attic in the name of the Areopagus (*Áreios Págos*) and, after Homer, the meaning 'frost, cold'. Other derivatives of *pḗgnumi* listed by Chantraine are *pagetós* 'frost', *pagerós* 'frosty, cold', *págiōs* 'firm, solid'; from the stem *pēg-*, we find *pēgós* 'solid, vigorous', *pēgás* 'hoar-frost, rime', and others, all suggesting a connection between 'firmness' and 'coldness'.
The *Brill Etymological Dictionary of Ancient Greek* (Beekes and van Beck, 2010) states that *págos* is derived from *págē* [f.] 'snare, trap, anything that fixes'. This dictionary does not provide any specific meaning for *págos* but, like the Liddell-Scott-Jones, asserts that its meaning is equivalent to that of *pagetós* 'frost'. The case of *págos* makes it clear that the criteria for identifying a prototypical sense can conflict with each other and prevent annotators from selecting one. Indeed, the earlier attestation of the sense in (3)i, 'crag, rock', instantiated by example (4), would lead to its selection as the prototypical sense (synset "n#06669293 | a lump of hard consolidated mineral matter"). However, this sense is employed in very specific contexts, often indicating the Areopagus in Athens (5). On the other hand, the higher frequency of sense in (3)ii, 'frost' shown in (6), suggests that this might be selected as the prototypical sense (synset "n#09741425 | the formation of frost or ice on a surface").

(4) *ou gàr ésan liménes*
NEG PTC be:IMPF.3PL harbor:NOM.PL
nēôn ókhoi,
ship:GEN.PL shelter:NOM.PL
oud' epiōgaí
NEG roadstead(F):NOM.PL
all' aktaì problêtes
but headland(F):NOM.PL projecting(F):NOM.PL
ésan spiládes te págoi te
be:IMPF.3PL reef(F):NOM.PL and rock:NOM.PL and
'for there were neither harbors where ships might ride, nor road-steads, but projecting headlands, and reefs, and cliffs' (Hom.*Od*.5.404-405)

(5) *hoi dè Pérsai*
DET PTC persian:NOM.PL
hizómenoi epì tòn
place:PTCP.PL upon DET
katantíon tês akropólios
over.against DET acropolis(F):GEN
ókhthon, tòn athēnaîoi
hill:ACC DET athenian:NOM.PL
kaléousi arḗion ***págon***
call:3PL of.ares:ACC **rock:ACC**
'The Persians took up a position on the hill opposite the acropolis, which the Athenians call the Areopagus.' (Hdt.8.52.3)

(6) *pou* ***págou*** *khuthéntos,*
where **frost:GEN** spread:AOR.PTCP
oîa kheímati,
such.as winter(N):DAT
xúlon ti thraûsai,
firewood(N):NOM any break:AOR.INF
taût' àn exérpōn
this PTC creep.out:PTCP
tálas emēkhanōmēn
wretched:NOM manage:IMPF.1SG

‘if when the frost had spread, as often happens in winter, a bit of firewood had to be broken, I would creep out in pain and manage it.’ (S.*Ph*.293)

Given the opaque nature of the difference between prototypical and non-prototypical senses, we decided to forgo accounting for such a distinction in our WordNets.

3.3 Literal vs. Non-literal Senses

The third basic idea of Cognitive Semantics is that complex sets of concepts can be referred to using simpler ones, through conceptual metaphor and metonymy. For this reason, in our WordNets, we have decided to distinguish between the literal, metaphorical, and metonymic senses of a word (see Section 2.2).

However, even a seemingly straightforward distinction like that between literal and non-literal senses proves problematic in some cases. One of these cases is when the sense(s) of a lemma can be analyzed diachronically as derived from a simpler or more concrete sense through metaphorical or metonymic processes, but such simpler sense is not attested in the history of the language. For example, the Latin verb *ferveo* (or *fervo*) ‘seethe, boil’ and *furo* ‘rage, be furious’ go back to the same Proto-Indo-European root **b^{h}erṷ-* ‘seethe, boil’, via two allomorphs, *feru(e)-* and *fur(o)-*, which were reassigned to separate paradigms (Kölligan, 2020). The link between boiling and rage is licensed by the conceptual metaphor ANGER IS A HOT FLUID IN A CONTAINER (Kövecses, 2010: 123; cf. also Lakoff, 1987: 383), which in turn derives from the more general ANGER IS HEAT via the BODY IS A CONTAINER metaphor. In Latin, *ferveo* retained both the literal (7)a and the metaphorical (7)b senses, whereas *furo* is primarily employed in the metaphoric sense of ‘rage, be furious’ shown in (8)a. However, *furo* is also found in contexts such as (8)b, where *furit* may in fact refer to magma of the volcano boiling underneath the earth. Finally, the deverbal noun *furor* ‘wrath’ only features the metaphorical meaning (9).

(7) *ferveo* ‘seethe, boil’ but also ‘be angry, rage’:

a. literal meaning

quin	*omnia*	*malit*
COMPL	all:ACC.PL	prefer:SBJV.3SG
quaecumque	*inmundis*	***fervent***
REL.NOM.PL	nasty:ABL.PL	be.hot:3PL
allata		*popinis.*
bring:PTCP.PRF.NOM.PL		eating.house:ABL.PL

‘It (the stomach) will prefer everything which is brought smoking hot from the nasty eating-houses.’ (Hor.*Sat*.2.4.61-62)

b. metaphorical meaning

animus	*tumida*	
heart:NOM	swelling:ABL	
feruebat	*ab*	*ira*
be.hot:IMPF.3SG	from	anger:ABL

‘His heart became hot with swelling anger.’ (Ov.*Met.*2.602)

(8) *furo* ‘rage, be furious’

a. metaphorical meaning

quo	*genere*	*Athamantem*	
REL.ABL	sense:ABL	Athamas:ACC	
Alcmaeonem	*Aiacem*		
Alcmaeon:ACC	Ajax:ACC		
Orestem	***furere***	*dicimus …*	
Orestes:ACC	be.furious:INF	say:PRS.1PL	

‘[the mind is influenced … by the stronger power of wrath or fear or pain,] in the sense in which we say that Athamas, Alcmaeon, Ajax and Orestes **are furious**.’ (Cic.*Tusc*.3.11)

b. literal meaning

ex	*imis*		*uero*
from	more.profound:ABL.PL		indeed
furit	*ignibus*	*impetus*	
rave:3SG	fire:ABL.PL	attack:NOM	
Aetnae			
Aetna:GEN			

‘the impetuous Aetna **raves** indeed from more profounder fires.’ (Lvcr.593)

(9) *furor* ‘wrath’

a. metaphorical meaning

cum	***caeci***	***furore***	*in*	
when	blind:NOM.PL	rage:ABL	into	
uolnera	*ac*	*ferrum*		
wound:ACC.PL	and	sword:ACC		
uecordi	*audacia*			
reckless:ABL	daring:NOM			
ruerent				
rush:SBJV.IMPF.3PL				

‘when they (the Astapans), **blind with rage**, rushed upon wounds and the sword with reckless daring.’ (Liv.28.22.14)

Given the situation presented above, *ferveo* should be annotated in our WordNet as having a literal sense ‘seeth, boil’ (synset “v#00261276 | bring to, or maintain at, the boiling point”) and a metaphorical one ‘rage’ (“v#01225618 | feel intense anger”), as both are attested in the history of Latin. In the case of *furor*, the sense ‘wrath’ (“n#05588321 | intense anger”) should be annotated as the literal one, as it is the only one attested in the texts. Finally, although we know that ‘rage, be furious’ is the result of a metaphorical shift, we should tag this sense as the literal sense of *furo*, as this is the primary meaning attested in the texts; cases like (8)b, on the other hand, can be seen as instances of personification, corresponding to English *angry sea* and belonging to the same personification process as Latin *mare placidum* ‘calm sea’.

The case of Latin *furo* and *furor* is different, for example, from that of Sanskrit *ghṛṇā-* (Proto-Indo-European **g^{hw}er-* ‘burn’; the Sanskrit root *ghar*, from which *ghṛṇā-* is derived, is not attested with verbal use; cf. EWA s.v.): for this noun, too, we know that from the literal sense ‘heat’ a metaphorical sense ‘compassion’ has been derived (through the metaphor AFFECTION IS WARMTH), which has then completely replaced the former sense. However, in this case, both meanings are attested in the history of

the language, the former in Vedic Sanskrit shown in (10) and the latter in Epic and Classical Sanskrit shown in (11). Therefore, in the Sanskrit WordNet, we annotate 'heat' ("n#07805780 | a form of energy that is transferred by a difference in temperature") as a literal sense and 'compassion' ("n#05615476 | a deep awareness of and sympathy for another's suffering") as a non-literal sense of *ghṛṇā-*.

(10)*párīm* ***ghṛṇấ*** *carati*
around heat(F):NOM go:3SG
titviṣé *śávo*
flare:PF.3SG.MID power(N):NOM
'Glowing heat encircles him [=Indra], and his vast power flared.' (*Ṛgveda* 1.52.6a)

(11)*ahiṃsā* *satya-vacanam*
non-violence(F):NOM sincere-word(N):NOM
ānṛśaṃsyam *dama*
kindness(N):NOM control:NOM
ghṛṇā
compassion(F):NOM
'non-violence, sincere word, kindness, control, compassion' (*Mahābhārata* 12, 80, 17.1; from de Rossi 2023: 93)

3.4 Metaphoric vs. Metonymic Senses

There are many cases where distinguishing between metaphor and metonymy becomes challenging, especially considering the standard definitions of metaphor and metonymy (cf. Goossens, 1990). As we have seen in Section 2.2, metaphor consists in conceptualizing one domain in terms of another (Lakoff and Johnson, 1980); in metonymy, an element within a domain provides access to another element within the same domain (Kövecses and Radden, 1998; Radden and Kövecses, 1999). Issues in distinguishing metaphor from metonymy arise in cases where it is unclear whether we are dealing with one domain or two, and this happens because some metaphors derive from metonymies (Kövecses, 2013: 78).

Take for instance the metaphor ANGER IS HEAT. In our folk model of emotions, the latter are seen as resulting in some physiological effects. Since anger is often accompanied by an increase in body temperature, sweating, and facial flushing, the conceptualization of anger in terms of increased body heat is licensed by the metonymy EFFECT FOR CAUSE. Paraphrasing it as THE PHYSIOLOGICAL EFFECTS OF AN EMOTION ARE THE EMOTION ITSELF, it becomes clear that the sole domain of EMOTIONS is involved here, and so we are dealing with a metonymy.

The conceptual metaphor ANGER IS HEAT arises from the cognitive process of generalization (Kövecses and Radden, 1998: 61; Kövecses, 2013: 80). If body heat is generalized into heat, a second domain, the one of TEMPERATURE, comes into play and becomes the source domain of a metaphor. In example (12), the verb *dah-* 'burn' is employed with reference to 'anger' (synset "v# 01248170 | feel strong emotion, esp. anger or passion"). Since this verb is usually referred to the burning of fire, and not to personal feeling temperature, we should probably annotate its use in (12) as metaphorical.

(12)*amarṣeṇa* *susampūrṇaḥ*
anger:INS fill:PTCP.PASS.PST.NOM
dahyamānaḥ *divāniśam*
burn:PTCP.PASS.NOM night.and.day
'I am full of anger, I burn day and night.' (*Mahābhārata* 2,43.21.1; from de Rossi 2023: 65)

Another emotion that is often conceptualized in terms of warmth is love, or romantic passion (13). Since love does not cause an increase in body temperature – though blushing may be an effect of it – the association appears to be an instance of a more general metaphor A STRONG EMOTION IS HEAT. From this it follows that LACK OF HEAT IS LACK OF EMOTION, and consequently LACK OF HEAT IS LACK OF LOVE (14).

(13)*et* *amore* ***ardeo***
and love:ABL burn:1SG
'And I burn with passion.' (Ter.*Eun*.72)

(14)***tepida*** *mens*
warm:NOM mind:NOM
'Cooled heart.' (Ov.*Ars*.2, 445)

The examples above demonstrate the difficulties that are often encountered in distinguishing between metaphor and metonymy, in general. This is especially true for ancient languages like those represented in our WordNets, for which we cannot rely on native speaker intuition to reconstruct the cognitive processes that license the non-literal meanings of a word.

4. Conclusions

In this paper, we have presented some challenges encountered in combining neo-structuralist and cognitive approaches to semantics for building WordNets of ancient languages. Indeed, although the architecture of our Ancient Greek, Latin, and Sanskrit WordNets follows the one of the original Princeton WordNet in many respects, we integrate notions of Cognitive Semantics.

This approach seems promising as it allows for a more fine-grained and "more realistic" representation of meaning, and thus facilitates studies in diachronic semantics and lexicology.

However, an initial annotation phase in our project has shown that some of the integrations initially planned can hardly be implemented in the relational database behind our WordNets. These difficulties partly arise from dealing with ancient languages for which we lack native speakers to judge the validity of our analyses. Other challenges stem from the need to achieve maximum granularity in meaning representation while maintaining a sustainable

workflow for annotators, who must be provided with guidelines that are clear and valid for the majority of lemmas they annotate.

For these reasons, we decided to forgo accounting for the distinction between the prototypical sense, that is, the sense that speakers identify as the most representative of a lexical unit (Evans, 2004: 92), and other secondary senses. In addition to the previously mentioned lack of native speakers for these languages, the difficulty in drawing such a distinction arises from the fact that the criteria for identifying a prototypical sense can conflict with one another, as demonstrated in Section 3.2 for Ancient Greek *págos* 'rock', 'frost'.

For the distinction between literal and non-literal senses, it is crucial to keep separate the senses reconstructed by the etymology of a lexeme from the ones actually attested in the history of the language. As a result, we treat Latin *furor* differently from Sanskrit *ghṛṇā-*. For *furor*, we can hypothesize that from a literal meaning related to 'boiling' (from the Proto-Indo-European root **b^{h}eru̯-*), a metaphorical meaning 'anger' has developed. However, since the latter is the only sense attested in the history of Latin, we must annotate it as literal. Similarly, for *ghṛṇā-* we know that from a literal meaning 'heat', a metaphorical meaning 'compassion' has developed, which then replaced the former. However, since both senses are attested in the history of the language, we annotate the former as literal and the latter as non-literal.

Finally, given the close relationship between metonymy and metaphor in some cases, it is not always possible to distinguish senses derived through one or the other cognitive process. Moreover, even if an in-depth study of a given semantic field allowed for an agreement on what is metonymic and what is metaphorical, such a workflow would not be sustainable for annotators, who are primarily BA and MA students in Classics and Linguistics, and not even for their supervisors, who would need to double-check the most complex cases one by one. On the one hand, the sometimes-blurry distinction would result in a low inter-annotator agreement; on the other hand, since dictionaries do not contain all the necessary information to maintain this distinction, annotators would have to look at individual examples in context, which is a very time-consuming process. For these reasons, in the next phases of the project, we limit ourselves to the distinction between literal and non-literal senses.

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8. Appendix A: abbreviations used in the glosses

The interlinear glosses used in the examples follow the Leipzig glossing rules (https://www.eva.mpg.de/lingua/resources/glossing-rules.php).

1	first person
2	second person
3	third person
ABL	ablative
ACC	accusative
AOR	aorist
COMPL	completive
DAT	dative
DET	determiner
F	feminine
GEN	genitive
IMPF	imperfect
INF	infinitive
INS	instrumental
MID	middle
N	neuter
NEG	negation
NOM	nominative
PASS	passive
PL	plural
PRF	perfect
PST	past
PTC	particle
PTCP	participle
REL	relative
SG	singular
SBJV	subjunctive

In glosses, the nominal number is specified only if it is plural or dual (singular is not indicated); similarly, gender is specified only if it is feminine or neuter (masculine is not indicated). Among verbal categories, present tense, indicative mood, and active voice are likewise not indicated.

9. Appendix B: authors and works cited in the examples

The abbreviations used in this paper are taken from the *Thesaurus Linguae Graecae* (https://stephanus.tlg.uci.edu/lsj/01-authors_and_works.html) for Ancient Greek examples and from the *Thesaurus Linguae Latinae* (https://thesaurus.badw.de/en/tll-digital/index/a.html) for Latin ones.

Cic. = M. Tullius Cicero
    Tusc. = *Tusculanae disputationes*
E. = Euripides Tragicus
    Rh. = *Rhesus*
Hdt. = Herodotus Historicus, Storiae
Hom. = Homerus Epicus
    Od. = *Odyssea*
Hor. = Q. Horatius Flaccus
    Sat. = *Saturae (sermones)*
Liv. = T. Livius Patavinus, *Ab urbe condita*
Lvcr. = T. Lucretius Carus, *De rerum natura*
Ov. = P. Ovidius Naso
    Ars. = *Ars amatoria*
    Met. = *Metamorphoses*
S. = Sophocles Tragicus
    Ph. = *Philoctetes*
Ter. = P. Terentius Afer
    Eun. = *Eunuchus*