Ontological approaches to morpho-semantics in Modern Greek derivation[·]

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Abstract
In the present article, we explore the affixational morpho-semantics of Modern Greek (MG) and how these can be expressed in the MMoOn ontology extension schema for MG. First, we set our approach by building on Lieber's lexical semantics model and Frame semantics. Accordingly, we adopt a flexible data-driven approach which attributes meaning to morphs horizontally, simplifies the way of this attribution and accounts for cases of morpho-semantic under-specification. Then, to corroborate our approach, we refer to some of the major issues in morpho-semantics such as affix polysemy, affix rivalry and morpho-semantic discrepancies. Afterwards, we try to represent all these cases in our ontological extended schema and provide some indicative SPARQL queries to prove the usability of our modelling.

Keywords
Linguistic Linked Data, Modern Greek derivation, Morpho-semantics, Ontological morphology

1. Introduction

Language morphology studies two major aspects of words: structure and meaning. By structure we refer to the decomposition of morphological units practiced in concatenative processes [9, 10] while word meaning consists of the individual semantic properties of morphs[1], ranging from pure grammatical, derivational or more extra-linguistic lexical meanings. These types of meaning are not static but are infiltrated within more complex structures during derivational processes. Namely, bits of morphological meaning are transferred onto new derivational entities (derived stems or words) comprising a process known as percolation [7]. Meaning, however, is not something that can stand alone but it is always expressed morphologically by form. And when we refer to form, we bear in mind its core representative unit, the morph, either a stem or an affix. What we are particularly interested is the morpho-semantics of affixes since it is this type of morph that plays a key role in complex derivational structures. More interestingly, form-meaning relation in affixes is not always one-to-one, but it is very frequent a specific form to have *n* meanings and a specific meaning to be expressed by more than one form. An instance of form may also happen to be identical with another instance of form, with both having completely different meanings. Other times form becomes inconsistent with the meaning of a structure, which, for example, we encounter in bracketing paradoxes or in conversion cases.

On the other hand, in ontological terms or NLP language representational models, morpho-semantics of affixes has not been dealt with sufficiently so far, since most of the models tend to describe their morpho-syntactic aspect (Ontolex, OLiA, Unimorph, Universal Dependencies etc.).

In this article, we deal especially with aspects of morpho-semantics of affixes and how these are processed ontologically within word structures. More specifically, in section 2, we focus on a couple of morpho-semantics approaches, describing related weaknesses and strengths. Then, we explain our approach and represent MG lexical examples ontologically. In section 3, we construct adequate SPARQL queries in the ontology to test our representational analysis in 2, and in section 4, we briefly summarize and conclude on the topic.

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[1] The terms *morph* and *morpheme* are used here interchangeably. Morph is the actual representation of a morpheme.

2. Morpho-semantics framework and Ontological representation

2.1. Morpho-semantics approach

Regarding morphological semantics in general, we will assume that there are three types of meaning: grammatical, derivational and lexical. The first pertains to the inflectional and syntactic function of units, including their POS category (i.e. inflectional affixes), the second to the abstract conceptual part dependent on the bases it is attached to (derivational affixes) and the third solely to extra-linguistic concepts (stems) [7]. We will define our approach for morpho-semantics building on Lieber's Conceptual Semantics (CS) framework [3, 4], which is in principle decompositional and consistent with the lexicalist approach. Lieber, defines a semantic skeleton of cross-categorial features that pertains to syntax accompanied by a body of encyclopedic meanings. Accordingly, she assumes that like simple lexemes, affixes have some independent meaning, beyond the effect of the argument structure of their base and that these bits of meaning tend to be unitary or closely related among them. To balance the semantic character of features cross-categorially she proposes basically two broad featural atoms, i.e. *material* and *dynamic*[2], to which she attaches binary (+/) or privative behavior. Figure 1 depicts Lieber's approach to affixational semantics in English and potentially in all languages. However, despite its flexibility to connect cross-categorially most of English suffixes by exploiting the semantic potential of those two features, her model has three core disadvantages:

- It is quite abstract in a way that it cannot be extended to more specific and autonomous affixational micro-meanings (e.g. evaluation, depreciation, profession, origin, doctrine or proponent to say a few), allowing the overgeneration of meanings [2].
- Despite its resourcefulness, the difference between binary (+/-) and privative semantic behavior is very indefinite. Additionally, one could oppose that should a feature be necessary to be absent, the presence of its opposite or the attribution of a more accurate feature would be sufficient. In other words, what would be the difference, if any, between +literate and -popular pertaining to style? Or if it would be necessary to define semantics more accurately (e.g. +colloquial or +demotic)[3] why wouldn't that be sufficient?

Class	*Simplex example*	*Derivational affix*
[+material]	chair, leg	
[–material]	time, fact	-ness, -ity, -hood, -ship
[+material, dynamic]	author, chef	-er, -ee, -ant, -ist
[–material, dynamic]	habit, war	-ation, -al, -ment, -ure
[+dynamic]	eat, kiss	
[–dynamic]	know, fond	-ic, -ive, -ary, -al,
[+dynamic, +IEPS]	fall, go, grow	
[+dynamic, –IEPS]	walk, run, vary	
causative*	kill	-ize, -ify

Figure 1: Lieber's model of binary and privative features to affixational semantics

- There is a lack of justification for cases of under-specification, where a feature is latent because there is no morph to carry its semantics or - otherwise put - there is a zero morph. For example, in Modern Greek (MG) there is no morph (inflectional suffix) in the noun *μητέρα* 'mother' to carry the Case and Number values (nominative, singular) or there is no derivational suffix present to change the POS category in the 'supposed' conversion of *οδηγώ* 'to drive' <> *οδηγός* 'driver' and vice versa.

[2] She also defines two other features, location and quantity.

[3] These may well be accompanied by additional features (e.g. +vulgar), if necessary, to determine style more accurately.

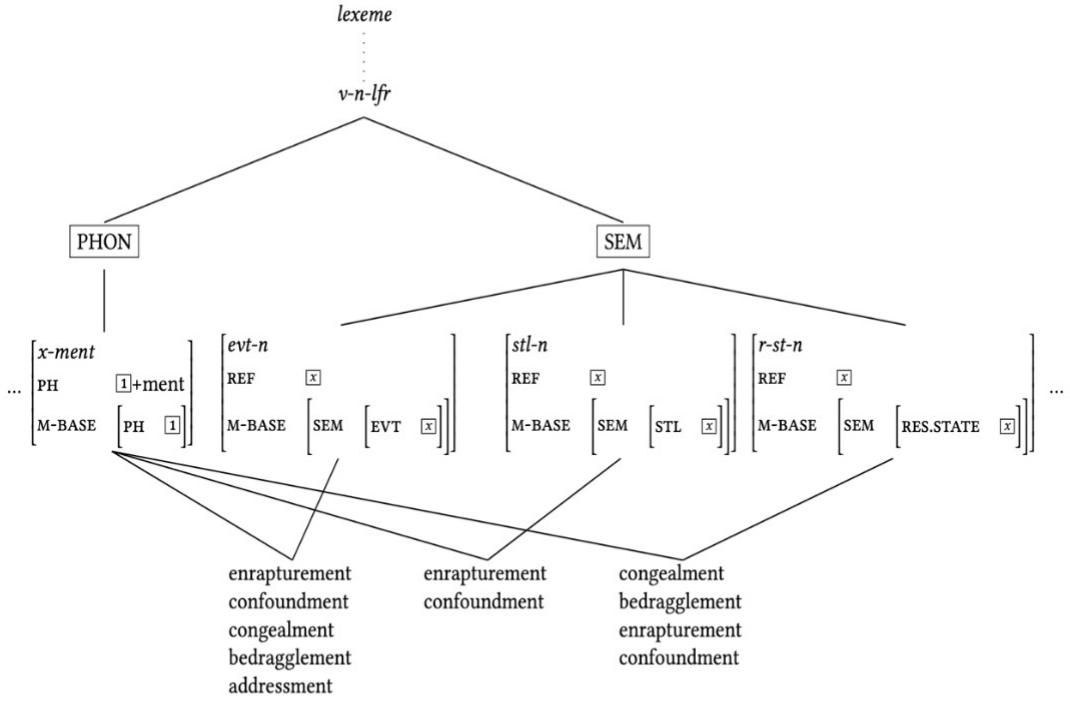

Figure 2: Representation of affix polysemy according to Frame Semantics

Inherently decompositional is also the Frame Semantics model [2, 5], which we cite here for analyzing affix polysemy. In Figure 2, we see how the three semantic instances of the suffix *-ment* (event, stimulus, result state) in English can be identified with each of the base argument. Each semantic attribute is connected to its value (*-ment1, -ment2, -ment3*) in the same way an ontology would connect two instances via an object property (e.g. has meaning). It is interesting here that all three different instances of *-ment* can be simultaneously found in the same lexical instance (e.g. confoundment), each of which is combined with the appropriate semantic argument of the verbal base (e.g. change-of-state-verbs, psych causation verbs etc.).

2.1. Our approach to morpho-semantics

To deal with CS framework lack of specificity we propose to:

- Extend feature semantics to all possible micro-meanings, either abstract or specific. We also assign these horizontally and not hierarchically.
- Disassociate +/- signs with featural semantics and assign (+) to features specified by the presence of a morph and (-) to features not specified by that presence. However, since in most cases a morph is present as the carrier of a semantic feature, it would be more economical to define just the feature *f* with no (+) signage at all (e.g. *f* and not *+f*). We should also note that in cases of morph absence, we generally assume that a zero-morph resides for carrying the latent or underspecified feature. This can be either derivational or inflectional, carrying normally the features of their present counterparts with the addition of a (-) sign.

Furthermore, to represent morpho-semantics ontologically:

- For affixational polysemy we define a morpho-semantic pattern *X1_1,* where the first number denotes the morphemic *form* and the second number divided by a hyphen _ the morphemic *meaning*.
- Thus, for multi-form morphemic instances (morph homonyms) we would have *X1_1, X2_1* etc. and for multi-meaning *X1_1, X1_2* etc.

For representing our model, we use the MMoOn[4] model, as we have done before. However, as we unfold the *Meaning* class of the model we have to make the following observations:

- The model attributes the same name to a class and an individual (e.g. *Diminution hastype Diminution* etc.) in the *Derivational Meaning* class, adopting OWL 2 punning technique. For now, we will not stick with that till we evaluate its functionality. However, the dividing of *Derivational Meaning* sub-categories is overall questionable as some derivational features can refer to more than one derivational class. For example, the *Diminutive* derivational meaning is used here only as a characteristic of *Noun Expansion*, which is not true in MG (see Table 1, *μικρός*$_{ADJ}$ 'small' > *μικρούτσικος*$_{ADJ}$ 'tiny' for adjectival diminution) while both *Diminution* and *Augmentation* would rather refer to a more abstract *Evaluation* category as subclasses.
- Categorial change representation (e.g. Adjectivization) would be more functional if it would incorporate both the initial and final category. As we have elsewhere observed [8], the categorial change can be incorporated in the *Meaning* class just once in the model, decongesting the *Morphological relationship* class. Thus, we proceed to form *X-X* and *X-Y* instances for *Expansion* and *Word-class Changing Derivation* respectively, representing the initial and the final category of the source and target word in one instance. Then, via the object property *owl:sameAs* we map each of the categorial combinations to the respective *mmoon* conceptualization, e.g. *ell_schema:N-Adj owl:sameAs mmoon:Adjectivization* etc. (Figure 3).

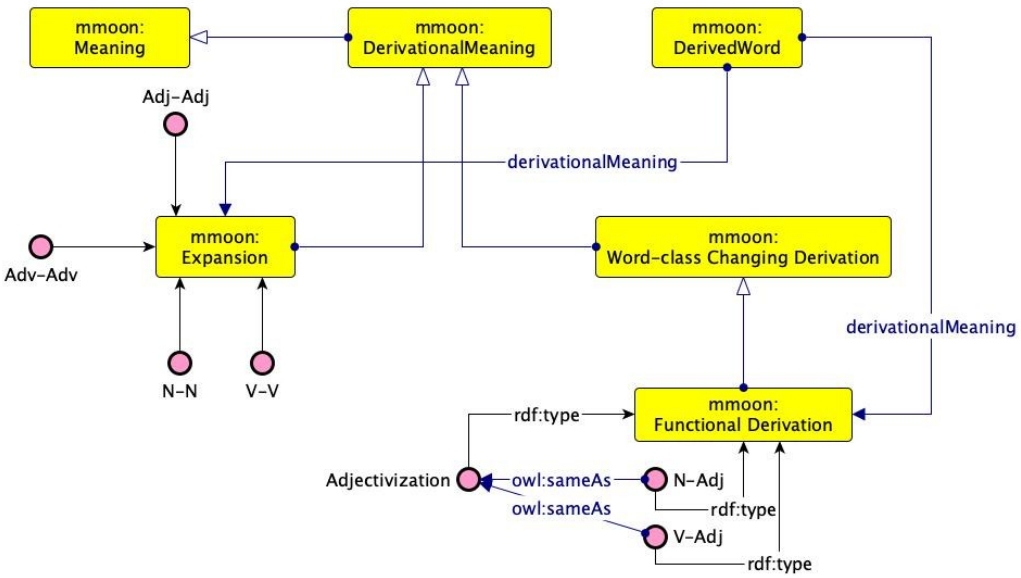

Figure 3: ell_schema enrichment with Expansion and Functional Derivation instances

Table 1
Multi-affix instantiation of one semantic feature

Grammatical category	Feature5	MG Morph	Input-Output word
adjective	diminutive	-ούτσικ-1_1 (-ος) etc. -ούλη-1_1 (-ς) etc.	μικρός > μικρούτσικος etc. μικρός > μικρούλης1 etc.
noun		-ούλη-2_1(-ς)	μικρούλης1 > μικρούλης2

[4] The ttl file of the MMoOn core model can be reached here: https://github.com/MMoOn-Project/MMoOn/blob/master/core.ttl.

- There are cases where closely related or identical meanings are repeated between types of derivation e.g. *Derivative Negation* in the *Expansion* class and *Privative Adjectivizer* in the *Semantic Derivation* class. Since affixes express abstract chunks of meaning that tend to be common between grammatical categories, it would be more economical and consistent to define a feature just once and use it for every type of derivation.

For example, in Table 1, we can view the analysis of affix rivalry [2] of the two suffixes *ούλη-* and *-ούτσικ-* attached to the same base *μικρ-*. In this case, we have to note that the two suffixes:

- Attach to the same base *μικρ-* (Adj)
- Belong to the same grammatical category, *-ούλη-* (Adj) and *-ούτσικ-* (Adj)
- Express the same derivational semantics, i.e. *diminutive*

Then, in Figure 4, we represent this analysis ontologically. It has to be noted, here, that the instances *μικρούλης1, μικρούλη-1* and *-ούλη-1* should be different from *μικρούλης2, μικρούλη-2 and -ούλη-2*, because $μικρούλης2_N$ has been derived from the conversion or the zero affix derivation of $μικρούλης1_{ADJ}$(*μικρούλης1* 'pretty small or young' > *μικρούλης2* 'the pretty small or young').

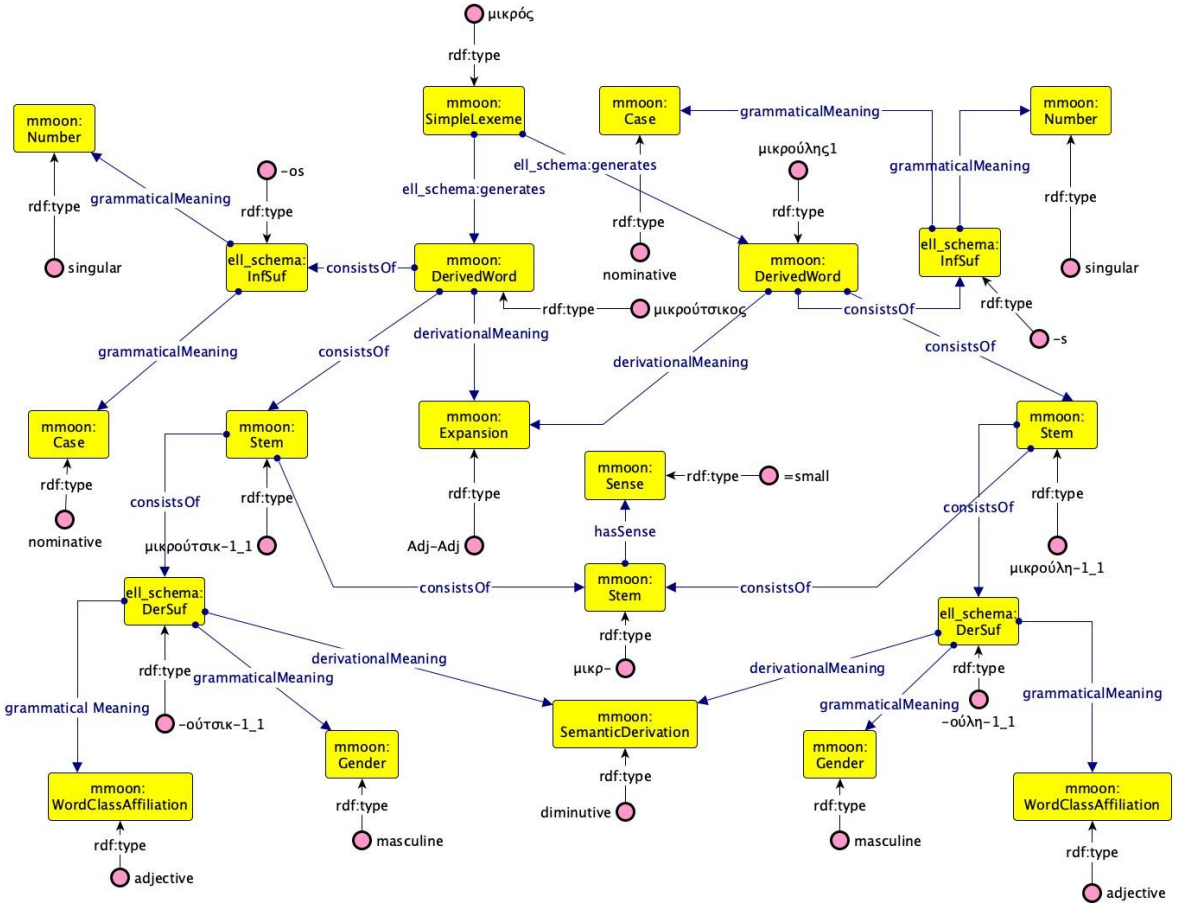

Figure 4: Representation of *diminutive* meaning between two affixes *-ούτσικ-1_1-* and *-ούλη-1_1*

In Table 2, on the other hand, we analyze a case of affix polysemy and in particular of suffix *-ιν-*, which:

- Is attached to nouns
- Denotes a *feature* closely related to the base. Therefore, its derivational meaning complements the argument and the lexical semantics of the base
- Has an adjectival grammatical meaning
- It expresses more than one meaning *-ιν-1_1, -ιν-1_2, -ιν-1_3, -ιν-1_4,* adhering to our pattern *X1_Meaning1/Meaning2/Meaning3/Meaning4.*

Table 2
Multι-semantic instances of one affix

Grammatical category	Feature	MG Morph	Input-Output word
adjective	quality/property	-ιν-1_1	αλήθεια > αληθινός
	origin	-ιν-1_2	Ζάκυνθος > Ζακυνθινός
	location or time	-ιν-1_3	κοντά > κοντινός νύχτα > νυχτερινός
	material	-ιν-1_4	χαλκός > χάλκινος

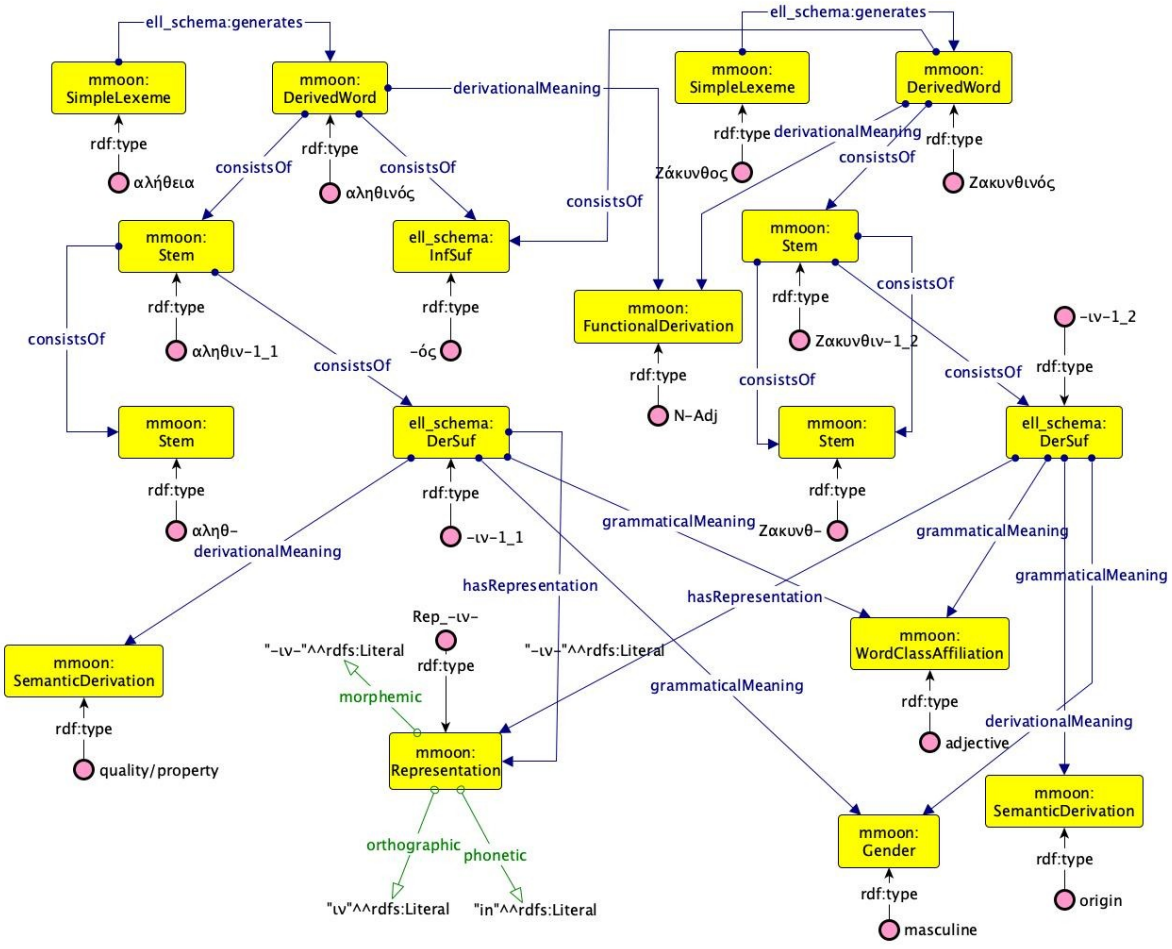

Figure 5: Representation of more than one meaning (quality/property and origin) related to affix *-ιν-*

In its ontological representation (Figure 5), we exploit the ontology class *Representation*, where all different semantic instances of *-ιν- (-ιν-1_1, -ιν-1_2, -ιν-1_3, -ιν-1_4)* end up to one common morphemic Representation instance *Rep_-ιν-*.

Finally, in Table 3, we analyze the homonymous but morphologically different morph *μετα-*. In the word *μετα-τρέπω* the morph *μετα-* is a prefix that comes from the grammaticalization of the preposition *μετά* [1, 6], while in the word *μετα-αποικιακός* the morph μετα- constitutes a confix that has been inserted in MG as a translation of the foreign prefix post- (post-colonial = μετα-αποικιακός).

Table 3
Morpho-semantic differentiations of the affix μετα-.

Grammatical category	Feature5	MG Morph	Input-Output word
-	μετα-1_1	change of situation	τρέπω > μετα-τρέπω
-	μετα-2_1	post	αποικιακός > μετα-αποικιακός

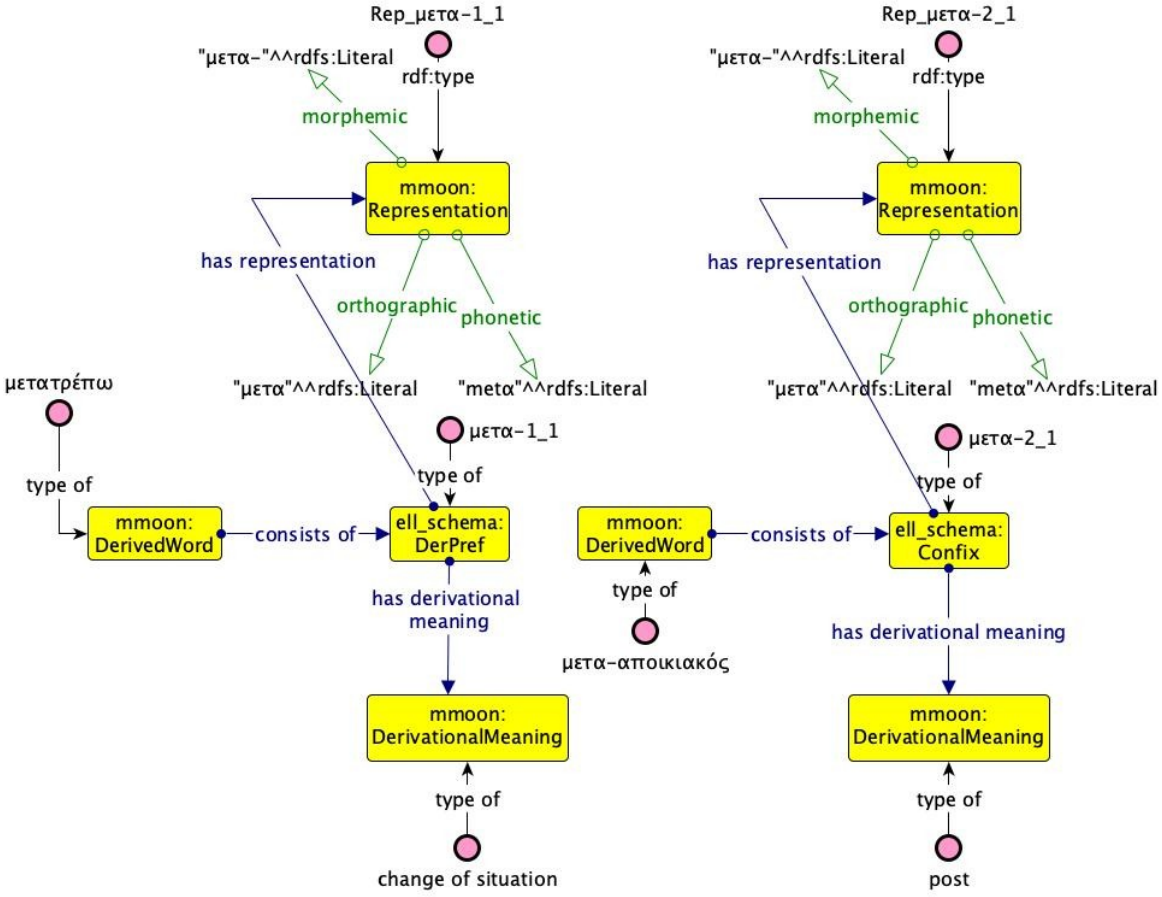

Figure 6: Morpho-semantic representation of the homonymous affix *μετα-*

Both morphs have the same representations, but they are completely different morphs. That is why, in Figure 6, we have created two different *Representation* instances, *Rep_μετα-1_1* and *Rep_μετα-2_1*.

2.2. Form-meaning mismatches

Usually, the morphological structure of a derived word corresponds to the semantic structure of that word. For example, the word *χορευτής* is morphologically structured according to its meaning:

$[[\text{χορευ}]_{V}\text{τής}_{N}]$ = someone that dances

There are times, though, where this morphological principle does not apply, forming a *bracketing paradox* e.g. the words *αχαρακτήριστος* 'someone that cannot be defined' or *αφύλακτος* 'someone that cannot be guarded' are structured according to the semantic structure in (1):

(1) *[α[χαρακτήρισ]$_{V}$τος$_{N}$]

which is basically ungrammatical because the prefix *α-* is attached only to nominal bases (Nouns, Adjectives) as depicted in (2):

(2) α[[χαρακτήρισ$_{V}$]τος$_{N}$]

One solution in (1) is that the possible words i.e. **χαρακτηριστός* and **φυλακτός* would be included in the MG lexicon [4] so that the prefix *α-* could be attached to them. The latter, however, would be not absolutely right because it would not depict the derivational process pragmatically and a further derivational rule would also have been necessary. What we propose instead is to create a morphemic discontinuous pattern of *α-_-τ-* that would attach to verbs like that (see Figure 7).

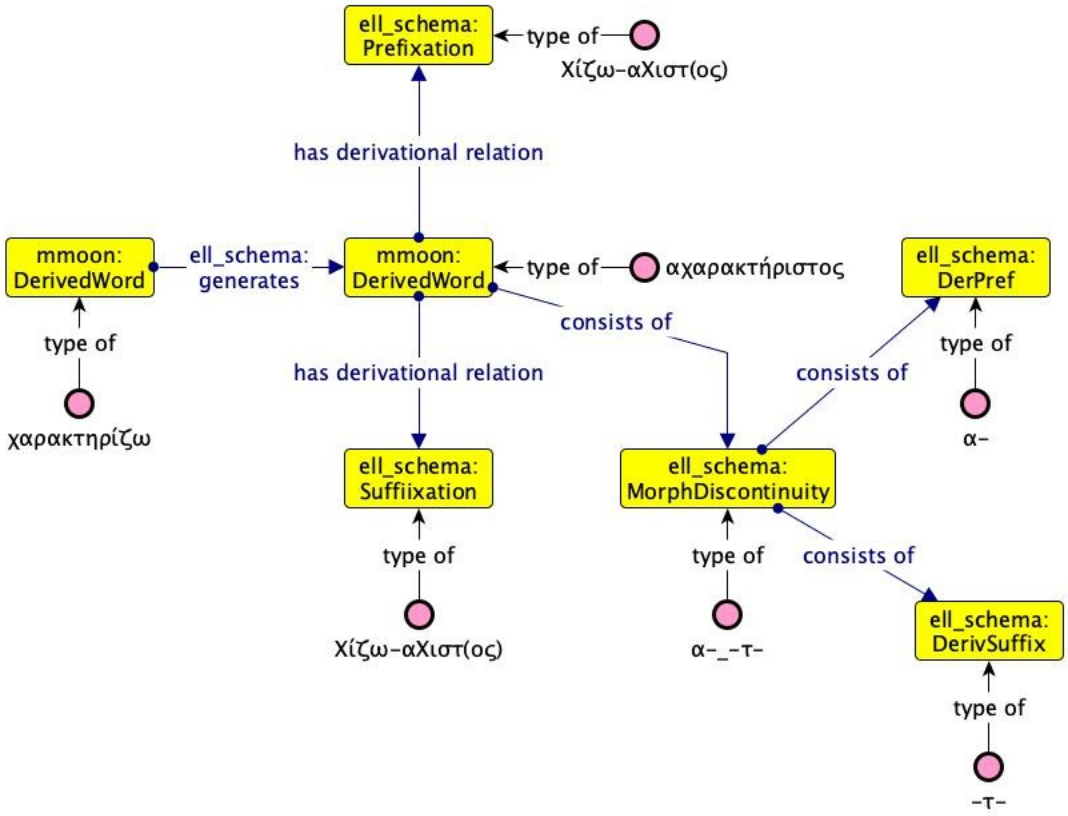

Figure 7: Representation of the *Morph discontinuity* instance *α-_-τ-*

This pattern would be rather preferable because it would explain similar productive cases with the addition of a double derivational rule (prefixation and suffixation): *φυλάσσω > αφύλακτος, χαρακτηρίζω > αχαρακτήριστος, προσδιορίζω > απροσδιόριστος, λυγίζω > αλύγιστος* etc. In Figure 7, we can view the representation of *χαρακτηρίζω > α-χαρακτήρισ-τος* as a double Prefixation and Suffixation derivational rule coming from the *α-_-τ-* pattern introduced as a *morph discontinuity* entity. This enables the implementation of two concomitant rules and bridges the form-meaning inconsistency. Then, because *α-_-τ-* is a complex entity, it should further consist of two morphemic sub-entities, i.e. the prefix *α-* and suffix *-τ*. It has also to be noted that this morph discontinuity takes the grammatical meaning of the suffix *-τ-*, adhering to the right head rule elaborated in [7].

What is more, there is often a special type of derivation, i.e. conversion, which is also called zero-marked cases affixation because of the absence of a derivational morph. In these cases, a change in meaning does not correspond to a change in form. Either there are times, where both directions between input and output word are possible e.g. *οδηγός* 'driver' <> *οδηγώ* 'to drive' [8] or there is just one direction possible (e.g. *Κρητικός* 'cretan' > *Κρητικός* 'inhabitant of Crete'). Rally [6] argues that the former are related to a conversion pleonastic rule while the latter can be explained by a zero

derivational suffix. Lieber [4] claims that "conversion is in fact not a form of derivation at all but rather is a form of lexical relisting of items" [5, p. 2116]. However, we think that this view lacks sufficient argumentation in terms of the change of the category. By contrast, and according to Ralli's view [6], we prefer to model two grammatically different bases *οδηγ-1* (nominal) and *οδηγ-2* (verbal) as start-offs towards the one word or the other. Then, we just have two derivational options: either *οδηγός > οδηγώ* or *οδηγός > οδηγώ* but not both simultaneously (see case (3) below and Figures 8, 9). To this problem, we think that the presence of a zero derivational suffix would provide sufficient justification for the change of the category in all the below cases (3), (4), (5) and (6), because it would be consistent with percolation, a process attested in MG [7]. We also divide this special type of suffix by grammatical category and gender: *zDerSuf1=noun/masculine, zDerSuf2=noun/feminine, zDerSuf3=noun/neutral, zDerSuf4=verb*). In this case, we define in place of conversion a suffixation rule:

From Verb to Noun and vice versa

(3) οδηγ1_{N} > οδηγός_{N} > $[[\text{οδηγ1}_{\text{N}}]\text{zDerSuf4}_{\text{V}}]$ώ
οδηγ2_{V} > οδηγώ_{V} > $[[\text{οδηγ2}_{\text{V}}]\text{zDerSuf1}_{\text{N}}]$ός

From Adjective to Noun

(4) $[\text{Κρητικ}_{\text{ADJ}}]$ός > $[[\text{Κρητικ}_{\text{N}}]\text{zDerSuf1}_{\text{N}}]$ός
(5) $[\text{νομικ}_{\text{ADJ}}]$ός > $[[\text{νομικ}_{\text{N}}]\text{zDerSuf1}_{\text{N}}]$ός

From Noun to Noun

(6) $[\text{κεφάλα}_{\text{N}}]$ > $[[\text{κεφάλα}_{\text{N}}]\text{zDerSuf1}_{\text{N}}]$ς
$[\text{γυαλάκια}_{\text{N}}]$ > $[[\text{γυαλάκια}_{\text{N}}]\text{zDerSuf1}_{\text{N}}]$ς

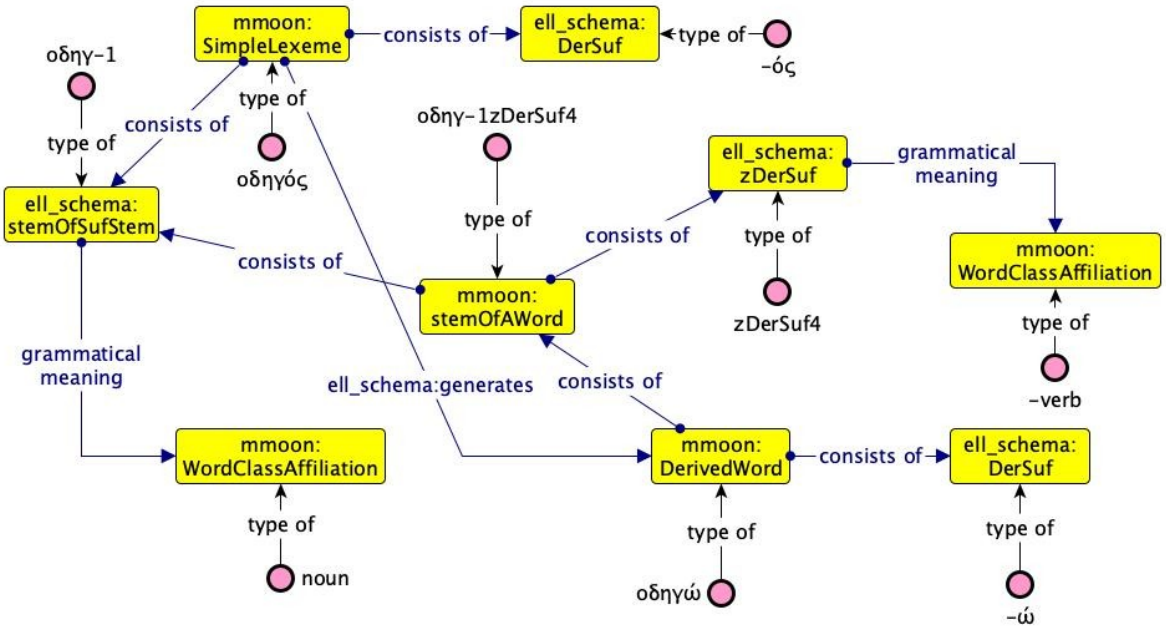

Figure 8: Representation of the derivational relation *οδηγός > οδηγώ*

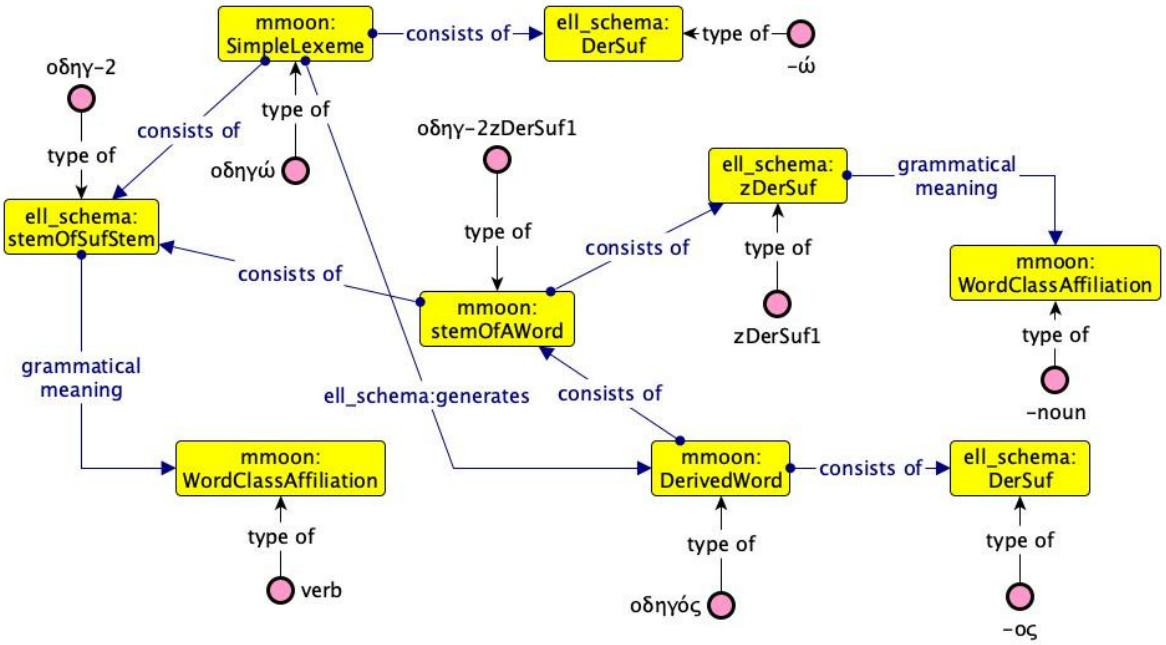

Figure 9: Representation of the derivational relation *οδηγώ* > *οδηγός*

3. Usability through SPARQL

To see the ontological applicability and usage of the previous morpho-semantic representations, in this section, we construct SPARQL queries for different morpho-semantic cases. For executing the queries, the respective SPARQL syntax is given below as well as the necessary prefixes referring to the used ontologies. These queries should be executed into the last version of Modern Greek inventory:

https://github.com/nvasilogamvrakis/mmoon_project/blob/main/inventory/finals/ell_inventory1.owl. This file also imports the last version of ell_schema: https://github.com/nvasilogamvrakis/mmoon_project/blob/main/ell_schema/finals/ell_schema1.owl as well as the MMoOn core ontology: https://github.com/nvasilogamvrakis/mmoon_project/blob/main/mmoon/mmoon_core.owl.

```
PREFIX : <http://mmoon.org/ell/inventory/omg/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX mmoon: <http://mmoon.org/core/>
PREFIX ell_schema: <http://mmoon.org/ell/schema/omg/>
```

3.1. Affix rivalry and polysemy

```
SELECT ?a ?b
        WHERE { ?a rdf:type ell_schema:DerSuf .
        ?a mmoon:derivationalMeaning ?b .}
ORDER BY ?b
```

3.2. Morph homonymy

```
SELECT ?a ?b ?c ?d
        WHERE { ?a mmoon:hasRepresentation ?b .
```

```
        ?b mmoon:morphemicRepresentation ?c .
        ?b mmoon:phoneticRepresentation ?d .}
ORDER BY ?a
```

3.3. Morph discontinuity entity

```
SELECT ?a ?b ?c
        WHERE { :χαρακτηρίζω ell_schema:ell_generates ?a .
        ?a mmoon:consistsOfMorph ?b .
        OPTIONAL { ?b mmoon:consistsOfMorph ?c .} }
```

3.4. Zero affix derivation

```
SELECT ?a ?b ?c
        WHERE { ?a rdf:type ell_schema:zDerSuf .
        ?a mmoon:belongsTo ?b .
        ?b mmoon:belongsTo ?c . }
ORDER BY ?a
```

4. Conclusion and Future research

In the previous analysis, we have dealt with aspects of morpho-semantics of affix atoms in MG derivation. We have placed our approach within Lieber's lexical semantics (LS) framework for its lexicalist character and for exploiting its *presence-absence semantics* in a way that is more accurate and functional. We also paralleled Frame Semantics approach to our modelling of different semantic connotation and have shown cases where a horizontal representation of featural micro-meanings can prove practical and consistent. We dealt specifically with issues of affix polysemy, affix rivalry or multi-form semantics and cases of conversion or zero affix derivation. In special cases such as bracketing paradoxes, we proposed a new morpho-ontological entity for bridging the morpho-semantic gap. All these issues were modeled in our extended MG schema of the MMoOn core ontology by adequate lexical examples and specific representational solutions were proposed. Finally, indicative SPARQL queries have been executed to test the linguistic usability of the examples in the ontology. In the research to come we aim to insert a minimum of language data into the ontology with carefully selected lexical instances so that specific SPARQL queries can be executed to analyze data morphologically according to related linguistic quests.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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