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# Noun Phrase and Prepositional Phrase Chunking for the Greek Language with spaCy

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Scientific paper

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## Abstract

In the need for Natural Language Understanding (NLU) various task should be done. As a short abstraction of this process, the text sentences should (a) be syntactically analysed and (b) semantically analysed. With semantic analysis we refer to some process that assigns the (meanings of) phrases constituting the syntactic (Phrase structure) tree to the semantic/thematic slots/roles that correspond to the frame (case grammar) of the sentence's verb (event). The most promising phrases to fill the semantic/thematic slots/roles of a verb (event) are noun phrases (np) and prepositional phrases (pp). Consequently the parser (the Syntactic analyser | the Phrase Structure analyser), either a deep or a shallow parser, should be able to isolate np and pp phrases.

An alternative approach for step (a) is to use a Dependency analyser and extract the Dependency structure/tree for each sentence. The Dependency structure/tree of a sentence provide the dependency (grammatical) relations between the words forming a sentence.

The resources needed for NLU are various and most of them are large, populous/crowded, demanding. Lexicons are used for recognizing the inflected forms of words and Frames are providing the relevant to the verb Thematic roles and their Selectional restrictions.

There are tools that provide abilities for Syntactic (Phrase structure) analysis or Dependency analysis that relieve us of the need to have our own Lexicons. However, it is not clear if these tools are able to provide all the promising phrase structures (np, pp, etc) needed for the semantic analysis

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step (b). We used such a tool for the Greek Language and the results are promising. However some programming is needed. Our experience and the created rules (software routines) are described in order other colleagues to be able to do same / similar tasks and to reduce the isolation for the rule-based NLU community (users and scientists).

**Keywords:** Greek language; extracting phrase structures; dependency parsing; prepositional phrase attachment; frame semantics; case grammars; natural language understanding

## 1. Introduction

In the need for Natural Language Understanding (NLU) various task should be done. As a short abstraction of this process, the text sentences should (a) be syntactically analysed and (b) semantically analysed. With semantic analysis we refer to some process that assigns the (meanings of) phrases constituting the syntactic (Phrase structure) tree to the semantic/thematic slots/roles (the Deep cases (Bruce, 1985) that correspond to the frame of the sentence's verb (event). (See also Case grammars (Fillmore, 1968; Bruce, 1985).) The most promising phrases to fill the semantic/thematic slots/roles of a verb (event) are noun phrases (np) and prepositional phrases (pp). Consequently the parser (the Syntactic analyzer | the Phrase Structure analyzer), either a deep or a shallow parser, should be able to isolate np and pp phrases.

An alternative approach for step (a) is to use a Dependency analyser (Jurafsky, 2019) and extract the Dependency structure/tree for each sentence. The Dependency structure/tree of a sentence provide the dependency (grammatical) relations between the words forming a sentence. A dependency tree depicts the head words (up) and the dependent words (down). The head word at the top is the Root of the Dependency tree. The arcs linking the vertices are labeled with the dependency (grammatical) relations. The advantage of Dependency trees is that the arguments to the verb are directly linked to it in the Dependency tree. Figure 1 depicts the dependency tree for the Greek sentence «Ο πρύτανης έδωσε συγχαρητήρια στους βραβευθέντες επιστήμονες» (The rector congratulated the awarded scientists), as it is created by spaCy (wikipedia SpaCy; spacy.io). The syntactic (phrase structure) tree for the same sentence and the equivalent for the translated in English sentence are in figures 2 and 3, correspondingly. There are methodologies for converting Dependency Trees to Phrase Structure Trees (Xia, 2001).

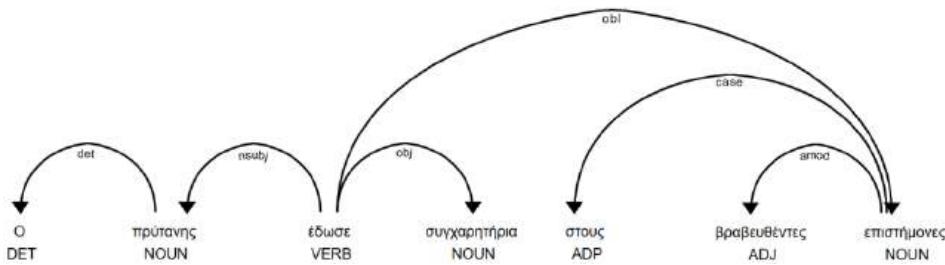


Figure 1. The dependency tree of the Greek sentence «Ο πρύτανης έδωσε συγχαρητήρια στους βραβευθέντες επιστήμονες», as it is created by spaCy.

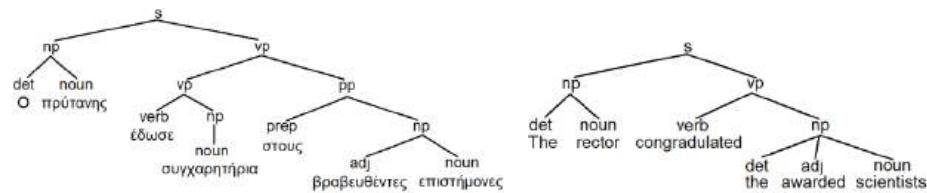


Figure 2. The syntactic (phrase structure) tree for the same Greek sentence.

Figure 3. The syntactic tree for the translated in English sentence.

The resources needed for NLU are various and most of them are large, populous/crowded, demanding. We only mention Lexicons and Collections of Verb Frames (Semantic Frames) (Fillmore 1992; Fillmore, 2001; Goldberg, 2010). Lexicons offer the information needed for programs that recognize all the inflected forms of a word and return the head (lemma), the part-of-speech, and the features (gender, number, and case for nouns, voice, tense, mood, number, and person for verbs, etc) of the given inflected word. Each Verb Frame is a model (the template and some rules) providing the relevant to the verb (event) Thematic roles (attributes), the Selectional restrictions (Bruce, 1985) for each Thematic role (conditions for a word/phrase/clause to become the value of the Thematic role), etc.

There are tools that provide abilities for Syntactic (Phrase structure) analysis or Dependency analysis that relieve us of the need to have our own Lexicons. However, it is not clear if these tools are able to provide all the promising phrase structures (np, pp, etc) needed to fill the Thematic roles and also check the Selectional restrictions imposed by Frames.

In this study, we are evaluating such a tool for the Greek Language. The tool is named spaCy (Wikipedia, spaCy; spacy.io). It is mentioned / characterized as «Industrial-Strength Natural Language Processing» and it is programmed with the Python programming language. It is published

under the MIT license. spaCy supports 75 languages, among them is the Greek language, and it offers dependency parsing.

In the following, we are presenting our methodology, the application of this methodology and the results and finally we are concluding and expressing our plans for future work.

## 2. Methodology

Our goal is to build a system (software module, else) that given a sentence, it will be able to produce the (mostly) nominal chunks of the sentence that could fill (by the intervention of a semantic analyzer) the slots (thematic roles) that the verb(s) of the sentence requires in order to have a valid meaning. In order to be able to implement our system correctly and for real data (and not as a toy) we decided to first build a set of sentences including all/most sentence types: simple sentences, augmented sentences, elliptical sentences, sentences with subordinate/dependent clauses, lined-up sentences. This set would be our test set for checking the ability of the result from our effort. The creation of the test set was the first step in our methodology.

Next (2<sup>nd</sup>) step in our methodology is to create the initial version of our approach (system). To do this, we used the readymade noun\_chunks routine for seeking the noun phrases and built the first procedure (routine) for seeking the prepositional phrases (pp).

The third (3<sup>rd</sup>) step in our methodology is the running of the so far defined system (approach) to the test set of sentences and getting the results (chunks) produced for each sentence of the set.

The fourth (4<sup>th</sup>) step in our methodology is to study the results and, if needed, build new rules (new routines) or improve existing rules (existing routines) for covering the situations that expected chunks are lost.

The last (5<sup>th</sup>) step, is to decide, according to the fourth step's results whether the goal is accomplished or there is a need to repeat the last 2 steps (3<sup>rd</sup> and 4<sup>th</sup>) until the goal is accomplished.

## 3. Application of Methodology and Results

Until now, we have repeated the loop (3<sup>rd</sup> to 5<sup>th</sup> steps) twice and we have defined five rules (routines) for extracting Nominal Subjects, Direct Objects, Indirect Objects, Prepositional Phrases and Clausal Complements:

```
get_dobjs(doc),  
get_iobjs(doc),  
get_nsubjs(doc),  
get_ccomps(doc),  
get_pps(doc).
```

Clausal Complements are actions which modify / complement other actions (a clausal complement fills a slot of another verb). For example in the sentence «είπα στον δάσκαλο ότι δεν διάβασα» (I told the teacher that I didn't read), the clause «ότι δεν διάβασα» (that I didn't read) complements the verb «είπα» (lemma «λέω», tell).

All of the mentioned 5 routines are based in a tree traversal where we seek either for specific part-of-speech nodes or specific Universal dependencies (de Marneffe, 2021) between nodes or a conjunction of both. Each item of the list of prepositional phrases (items of list returned by `get_pps`) and the list of clausal complements (items of list returned by `get_ccomps`) has 5 elements: number of first and last token, introductory keyword (usually a preposition or a subordinating conjunction), head word, and the syntactic (phrasal structure) subtree. Each item of the other three lists has 4 elements: number of first and last token, head word, and the syntactic (phrasal structure) subtree.

We are now running the fourth (4<sup>th</sup>) step in the third repetition of the loop (steps 3 to 5) and now we are building a clever split of sequences of prepositional phrases. This is because there are cases of prepositional phrase attachment (Olteanu, 2005; Nadh, 2009; Ratnaparkhi, 2021) mistakes and we prefer to allow later steps in Natural Language Understanding (NLU) systems (e.g. a semantic analyser) to decide which the correct prepositional phrase attachment is. For example in the sentence «Ο Πρύτανης έδωσε συγχαρητήρια στους βραβευθέντες επιστήμονες κατά την έλευση τους στην αίθουσα τελετών» (The Rector congratulated the awarded scientists upon their arrival in the ceremony hall), spaCy assigns to the remaining after the direct object word «συγχαρητήρια», assigns to the underlined part of sentence the «obl» relation with the verb. See figure 4 for the dependency parsing tree returned by spaCy and also the «obl» relation of the underlined part of sentence with the verb.

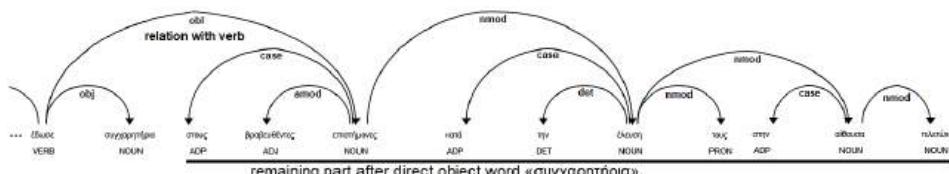


Figure 4. the dependency tree returned by spaCy.

The underlined sentence part (clause) is equivalent (can be transformed) to a constituency parsing tree (phrase structure tree), as depicted in figure 5.

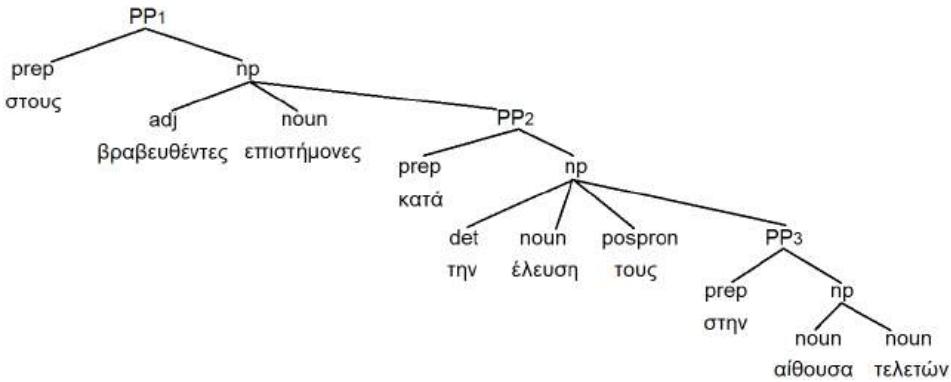


Figure 5. The equivalent constituency parsing tree (phrase structure tree) for whatever follows after the direct object word «συγχαρητήρια» of the sentence.

The same constituency parsing tree can be also depicted with the simplified nested form:

PP<sub>1</sub>(στους βραβευθέντες επιστήμονες PP<sub>2</sub>(κατά την έλευση τους PP<sub>3</sub>(στην αίθουσα τελετών))).

From all the above depictions (figures 2 and 3, and the simplified nested form) it is obvious that the prepositional phrase attachments that spaCy decided for the underlined part of sentence are semantically incorrect. Consequently, the meaning of the underlined sentence part can't be a filler for any of the thematic roles that the verb «δίνω» (lemma of inflected word «έδωσε») can have. A simple partitioning (based on part-of-speech preposition, «prep» in figure 2, or «ADP» in spaCy) algorithm can return the following 3 flattened Prepositional Phrases (PP):

PP<sub>1</sub>(στους βραβευθέντες επιστήμονες κατά την έλευση τους στην αίθουσα τελετών),

PP<sub>2</sub>(κατά την έλευση τους στην αίθουσα τελετών),

PP<sub>3</sub>(στην αίθουσα τελετών).

Our clever split of sequences of prepositional phrases can also produce the following PPs:

PP<sub>1a</sub> (στους βραβευθέντες επιστήμονες),

PP<sub>2a</sub> (κατά την έλευση τους),

PP<sub>1b</sub> (στους βραβευθέντες επιστήμονες κατά την έλευση τους).

Later, a semantic analysis module having all the above (6) alternative PP can assign the thematic role Location of verb «δίνω» to PP<sub>3</sub>, assign the semantic role Beneficiary to PP<sub>1a</sub>, and assign the semantic role Time to PP<sub>2a</sub>.

We are also investigating if we should return a list of nodes having the universal dependency «acl:relcl» whenever an action modifies/complements/determines a noun. For example, in the clause «τον πυροσβέστη που έσβησε τη φωτιά» (the firefighter who put out the fire), the action «έσβησε τη φωτιά» (put out the fire) determines the noun «πυροσβέστη» (firefighter).

Other similar universal dependency relations we are investigating are:

- acl, it is a more general relation that points to an action that modifies / complements / determines a noun,
- xcomp, it is a relation that points to an action that modifies / complements another action (fills a slot of another verb).

#### 4. Conclusions and future work

The tool we investigated provides dependency analysis and that relieve us of the need to have our own Lexicons. However, it does not offer all the phrase structures needed for the semantic analysis step. The isolation only of np and pp chunks (the later programmatical) is not enough. We have to experiment to find what kind of universal dependencies and what kind of part-of-speech nodes should be investigated to extract more chunks valuable for the semantic analysis. Moreover some more programming is needed to overcome mistakes that the dependency analysers impose. For example the prepositional phrase attachment mistakes have been resolved programmatical. Our overall experience and the results for the Greek Language are promising. We hope that other colleagues will be able to do same / similar tasks and altogether to reduce the isolation for the rule-based NLU community (users and scientists).

Scientists in rule-based NLU and NLG technologies are offering reliable, transparent and deterministic language technologies but they are working isolated. On the other hand, there are generative AI companies offering powerful and productive systems, but till now unreliable. As a consequence, rule-based NLU & NLG technologies are losing space in the market in the name of productivity. The results of paper prove that we can combine rule-based accuracy with generative AI productivity and achieve creativity and fluency with control and precision for the language tools. We are reviving the interest for rule-based NLU. Generalizing, we are reviving the interest for knowledge-driven systems.

In our set of Greek sentences (see Appendix B), we have not included sentences having multiple subjects or having multiple subject predicative (MS or MSP). It is also having only one sentence with lined-up

sentences (clauses). We are planning to extend our set of Greek sentences to include such kind of sentences and reevaluate our system's effectiveness. Next, we are planning to implement routines that isolate clauses having the universal relations of «acl:relcl», «acl», «xcomp» and else.

## Appendix A – Terminology

Some of the terms used can possibly create ambiguity. To overcome, we provide the following table of Greek and English terminology.

Term in English bibliography	Term in Greek bibliography	Description / Explanation, if needed
simple sentence	απλή πρόταση	One independent clause.
-- use the description	συνθέτη πρόταση	A sentence having multiple subjects (MS) or having multiple subject predicative (MSP)
augmented sentence	επαυξημένη πρόταση	A sentence in which there are complements to the main terms.
elliptical sentence	ελλειπτική πρόταση	A sentence that there are missing terms.
<del>complex sentence</del> a sentence with subordinate / dependent clauses	Πρόταση με δευτερεύουσες ή εξαρτημένες προτάσεις	A sentence with subordinate / dependent clauses. The translation of English term to Greek (σύνθετη πρόταση) has another meaning. To avoid conflict, for English we will use the description.
<del>compound sentence</del> lined-up sentences	Παρατακτική σύνδεση προτάσεων	Two or more independent clauses. The English term «compound sentence» is translated to «συνθέτη πρόταση» that is used for other reason. We prefer to use the term lined-up sentences
mood	έγκλιση	The speaker's attitude towards the action (Indicative, Subjunctive, Imperative, ...)

## Appendix B – Set of Greek sentences for testing Natural Language Processing (NLP) and Natural Language Understanding (NLU) systems.

'Ο Παναγιώτης πήγε στο θέατρο με το λεωφορείο'.....	1
'Ο Παναγιώτης πήγε στο θέατρο με τη Δήμητρα' .....	2
'Ο Παναγιώτης πήγε στο θέατρο με το προαστιακό λεωφορείο'.....	3
'Ο Παναγιώτης πήγε στο θέατρο με την όμορφη Δήμητρα' .....	4
'Ο Παναγιώτης πήγε στο θέατρο με την αγαπημένη του θεία' .....	5
'Ο Παναγιώτης πήγε στο θέατρο με τη θεία Σούλα'.....	6
'Ο Παναγιώτης πήγε στο θέατρο με τη θεία Δήμητρα' .....	7
'Ο Παναγιώτης πήγε στο θέατρο με τη θεία του' .....	8
'Ο Παναγιώτης πήγε στο θέατρο με τη θεία του με λεωφορείο' .....	9
'Ο Γιώργος πήγε τη Δήμητρα στο ξενοδοχείο' .....	10
'Ο Γιώργος πήγε στο ξενοδοχείο με τη Δήμητρα' .....	11
'Ο Βαγγέλης έστριψε προς το γείτονα με την υψηλή περίφραξη' .....	12
'Ο Βαγγέλης έστριψε προς το γείτονα με το ποδήλατο του' .....	13
'Η Ελένη στράφηκε προς το σκύλο με την μαύρη ουρά' .....	14
'Η Ελένη έδιωξε το σκύλο με ένα ξύλο' .....	15
'Η Ελένη έδωσε τον αναπτήρα στην γιαγιά της' .....	16
'Ο Περικλής οδήγησε το αυτοκίνητο με μεγάλη ταχύτητα' .....	17
'Ο Περικλής ταξιδεύει για το χωριό του με το αυτοκίνητο του πατέρα του' .....	18
'Ο Περικλής ταξίδεψε στο χωριό του με τον προαστιακό σιδηρόδρομο' .....	19
'Έδωσα στον Άγγελο το τετράδιο' .....	20
'Έβαλα το νερό στο ψυγείο'.....	21
'Πήρα από τον πατέρα μου το αυτοκίνητο' .....	22
'Είπα στον καθηγητή μου ότι δεν διάβασα' .....	23
'Φέρατε το φαγητό του σκύλου;' .....	24
'Φέρατε το φαγητό για τον σκύλο;' .....	25
'Ο νόμος επιβάλει φόρο 15% επί των εσόδων' .....	26
'Σου δανείζω τα χρήματα υπό την προϋπόθεση ότι θα τα επιστρέψεις μέχρι τον Αύγουστο' .....	27
'Η Ευρωπαϊκή Επιτροπή χορήγησε άδεια κυκλοφορίας υπό όρους για το πρώτο εμβόλιο κατά της νόσου COVID-19'.....	28
'Ο Πρύτανης έδωσε συγχαρητήρια στους βραβευθέντες επιστήμονες κατά την έλευση τους στην αίθουσα τελετών' .....	29

'Οι οικοδομικές εργασίες θα ξεκινήσουν μετά την έκδοση της οικοδομικής αδείας'	30
'Οι γεωργοί ραντίζουν τα δέντρα τους με χαλκό κατά τη διάρκεια του Φεβρουαρίου'	31
'Οι προκομένοι γεωργοί ραντίζουν τα καρποφόρα δέντρα τους με χαλκό πριν το μήνα Φεβρουάριο'	32
'Ο Θανάσης ταξιδεύει στο χωριό του με το αυτοκίνητο του πατέρα του'	33
'Ο Θανάσης ταξιδεύει στο δρόμο που ενώνει τη Θήβα με τη Λειβαδιά'..	34
'Η Αδαμαντία έφαγε τα μακαρόνια με ένα κουτάλι στην αυλή του σπιτιού της'	35
'Η Αδαμαντία αγόρασε μπριτζόλες από βόειο κρέας'	36
'Η Αδαμαντία αγόρασε μπριτζόλες από βόειο κρέας από ενήλικα ζώα' ..	37
'Η Αδαμαντία αγόρασε μπριτζόλες από βόειο κρέας από ενήλικα ζώα που εκτρέφονται στην Μεσσηνία'	38
'Η Αδαμαντία αγόρασε μπριτζόλες από βόειο κρέας από ενήλικα ζώα από ένα χασάπικο στα Πετράλωνα'	39
'Η νέα συγκάτοικος της Αδαμαντίας αγόρασε μπριτζόλες από βόειο κρέας από ενήλικα ζώα από ένα χασάπικο στα Πετράλωνα'	40
'Ο διευθυντής του τμήματος εγκαταστάσεων μου είπε την αιτία διαφωνίας του με τον προϊστάμενο του τμήματος μηχανολογικών κατασκευών'	41
'Συνάντησα τον πυροσβέστη που έσβησε την φωτιά στα Σάλωνα πριν μία εβδομάδα'	(23b) 42
'Του δανείζω τα χρήματα υπό την προϋπόθεση ότι ο Παναγιώτης θα μου επιστρέψει τα δανεικά μέχρι τον Αύγουστο'	(27b) 43
'Ο εργοδηγός θα στείλει στον Παναγιώτη τα εργαλεία και θα περιμένει αυτός να του επιστρέψει την μηχανή'	(27c) 44

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## Imeničke i predložne sintagme u grčkom jeziku pomoću spaCy biblioteke

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### Sažetak

Za razumevanje prirodnog jezika potrebno je obaviti više zadataka. U pojednostavljenom prikazu, rečenice treba analizirati (a) sintakšički i (b) semantički. Pod semantičkom analizom podrazumeva se proces dodeljivanja značenja frazama koje čine sintakšičko stablo, i to semantičkim/tematskim ulogama (slotovima) koje odgovaraju semantičkom okviru glagola u rečenici (događaju). Najpogodnije fraze za popunjavanje tematskih uloga glagola jesu imeničke sintagme (NP) i priloško-predloške sintagme (PP). Zbog toga bi parser (sintakšički analizator ili analizator frazne strukture), bilo duboki ili plitki, trebalo da bude u stanju da izoluje imeničke fraze i PP sintagme.

Alternativni pristup koraku (a) jeste upotreba analizatora zavisnosti (Dependency analyser), koji izvlači zavisnosnu strukturu/stablo za svaku rečenicu. Zavisnosno stablo prikazuje gramatičke odnose između reči koje čine rečenicu.

Za razumevanje prirodnog jezika su potrebni različiti resursi, uglavnom obimni, složeni i zahtevni. Leksikoni služe za prepoznavanje flektivnih oblika reči, dok okviri (frames) obezbeđuju odgovarajuće tematske uloge glagola i njihova ograničenja.

Postoje alati koji omogućavaju sintakšičku analizu ili analizu zavisnosti i tako nas oslobođaju potrebe da održavamo sopstvene leksikone. Ipak, nije sigurno da li ti alati mogu da obezbede sve potrebne

strukture polileksemских јединица (NP, PP итд.) за семантичку анализу у кораку (b). Користили smo такав алат за грчки језик и резултати су охрабрујући — мада је потребно додатно програмирање. Наše искуство и kreirana правила (у виду softverskih rutina) су описана у раду како би и други истраживачи могли да обављају исте или сличне задатке и time смање изолованост zajednice која radi на приступима заснованим на правилма за аутоматско разумевање природног језика.

**Ključне речи:** грчки језик; екстракција полилексемских структура; анализа зависности; прилошко-предлошке синтагме; семантика оквира; разумевање природног језика