A Preliminary and Novel Computational Application of Relational Grammar for the Greek Language

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Abstract: - This paper presents a first implementation of Relational Grammar in the Modern Greek Language, with an analysis of the basic laws and principles. Relational Grammar is a linguistic framework developed in the early 1970s as an alternative approach to Transformational Grammar. Relational Grammar distinguishes itself by focusing on the independence of grammatical relations from the phrasal status of terms and by making subject–object relations fundamental to syntactic analysis, rather than treating these relations as derived from phrasal structure. The approach herein is explained with several examples from Modern Greek.

Key-Words: - Relational Grammar, strata, Chômeur, Grammatical Relations, Universal Dependencies, Modern Greek

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1 Introduction

Relational Grammar (RG) is a linguistic framework developed primarily by David Perlmutter and Paul Postal in the early 1970s as an alternative approach to Chomsky's *Transformational Grammar* (TG) [1]. It was first presented to a wide audience at the *Linguistic Society of America's* (LSA) *Summer Linguistic Institute* in Amherst, Massachusetts (USA) in 1974. RG focuses on *Grammatical Relations* (GRs) as *primitives* for reading and analyzing the syntax of languages and moves away from the traditional approach to verbal structure.

The Greek language is an excellent field of study for RG, as it features *free word order*, *rich morphology*, and *a clear distinction of cases*, which facilitate the identification of grammatical relations.

2 Basic Concepts and Terminology

Primary grammatical relations, according to RG, are universal and hierarchically organized:

- 1 (Subject): The term is traditionally associated with the role of the agent, the bearer of the action, or the subject of a property. It usually controls agreement with the verb.
- 2 (Direct Object): The term that directly accepts the action of the verb.
- 3 (Indirect Object): The term that is indirectly affected by the action of the verb, often the recipient or the beneficiary.
- P (Predicate): The verb and its complements that assign a property or action to the subject.
- N (Nonterms/Oblique GRs): They include prepositional phrases (e.g., of place, time, manner, means), genitive modifiers, etc. These terms bear semantic roles that are not the primary GRs (1, 2, 3).
- Cho (Chômeur): A special grammatical relation assigned to a term when it loses its original GR because another term occupies that position in the same stratum. For example, in the passive, the original subject (1) becomes a Chômeur.

Relations 1, 2, and 3 are collectively referred to as *terms*. Relations 1 and 2 are collectively known as

nuclear relations, while 2 and 3 are known as *object relations*.

RG is a *multi-stratal* theory, which means that sentences are analyzed in successive levels or *strata*. Each stratum represents the grammatical relations [2] of the terms at a specific point in the derivation of the sentence. Syntactic rules are described as changes in the grammatical relations of the terms from one stratum to the next, rather than as movements of phrases. The universality of RG allows syntactic phenomena to be compared across different languages in a more direct way.

Changes in the grammatical relations of nominal elements between strata are called *Revaluations*. These include:

- *Advancements*: When a nominal moves "up" in the hierarchy, e.g., from 2 to 1 (passive voice).
- *Demotions*: When a nominal moves "down" in the hierarchy, e.g., from 1 to Chômeur.

3 Basic Laws and Principles

To ensure the consistency and universality of the theory, RG includes a set of six laws, presented in the next subsections.

3.1 Stratal Uniqueness Law (SUL)

A fundamental law in RG, which states that in any given stratum, there can be at most one nominal that bears a particular term relation (1, 2, or 3). In simpler terms, a sentence cannot have more than one subject, one direct object, or one indirect object. If a term acquires a GR that is already held by another term in the same stratum, the original holder becomes a *chômeur*. This principle is central to understanding phenomena such as the passive voice.

However, RG has faced difficulties in applying the SUL in certain languages, especially those that exhibit *double object constructions*, where *two objects* appear to share the same grammatical relation, as in Arabic (apparently double direct objects), Kinyarwanda (multiple objects), and Korean (apparently double objects).

Although the above cases appear to violate the SUL, RG theorists argue that the law *holds universally*. The solution they propose is a *stratal analysis*, in which each sentence has multiple levels of structure, or "strata." Any phenomenon that appears to violate the law on the surface is analyzed as the result of a series of advancements or demotions between strata, so that the SUL is strictly maintained in each individual stratum [3], [4], [5].

3.2 Final 1 Law

Every sentence must have a *subject* (1) at the *final level* (*stratum*) of its syntactic structure. In other words, regardless of the syntactic changes that may occur in a sentence (e.g., passive voice), the final result must be a sentence with a clear subject, even if it is *unpronounced* (as in Greek, with pro-drop / null subject).

3.3 Oblique Law

If a *nominal* bears an oblique relation in a sentence, then it already bears it from the *initial stratum*; in other words, *oblique relations are not acquired in later strata* (*post-initial*). However, Joseph showed that Greek, in a special case, exhibits *Raising-to-Oblique*, which *contradicts* the very general version of the law (which would prohibit any "acquisition" of an oblique) [6], and he proposes a revised law so that oblique positions, including prepositional ones, can serve as licit targets of ascension [7].

3.4 Motivated Chômage Law

Demotions to chômeur status are *never spontaneous* but occur only when another nominal usurps the relation by advancement. In simpler terms, the Motivated Chômage Law states that the syntactic change leading to the loss or demotion of a subject (e.g., in passive sentences) always happens for a specific syntactic reason and not by chance. This principle confirms that Chômage is always "motivated" by the assumption of a GR by another term. There cannot be a Chômeur term without a "promoted" term that has replaced it in the RG hierarchy.

3.5 1-Advancement Exclusiveness Law - 1AEX

This law prohibits two different nominals from being promoted to *subject* (1) in the same sentence. That is, only one element that was not originally a subject can be upgraded to a subject. Once a promotion to 1 has taken place, *no other* promotion to 1 is possible within the same verbal structure. A characteristic example of its application in Greek is *passivization*, where the direct object (2) changes its basic relation and becomes the subject (1), while at the same time the indirect object cannot also undergo the same process (thus avoiding *double passivization*) [8].

3.6 Relational Succession Law - RSL

A fundamental law of Relational Grammar that places constraints on how grammatical relations change within a sentence. Essentially, the RSL specifies which new grammatical relation an element

may assume when its previous relation has been demoted. When a term such as the subject (1) or the object (2) loses its grammatical relation in a sentence and becomes a *chômeur* (a term that has been demoted and deprived of its original relation), any other term that takes its place must be the term closest to it in the hierarchy of grammatical relations.

4 Significant Syntactic Phenomena and RG Analyses in the Greek Language

The Greek language, with its rich inflectional morphology and relatively free word order, presents particular characteristics that RG can analyze effectively. Its application to Greek can help in understanding syntax, especially in phenomena such as:

- *The structure of the passive voice*: How the direct object of an active sentence becomes the subject in the passive.
- *Cases of raising and clause union*: Where constituents from one structure become constituents of another.
- *Changes in grammatical relations*: How certain objects or modifiers can be promoted or demoted in different syntactic constructions.

4.1 Emphasis on Grammatical Relations

The Greek language expresses grammatical relations (subject, object, etc.) mainly through the *case marking* (nominative, accusative, genitive) of nouns and pronouns, rather than through word order in the sentence. RG, which places precisely these relations at the core of its analysis, is ideal for this. It does not depend on linear order, which is a major advantage for Greek.

In Greek, the *subject* is in the *nominative* case, agrees with the verb, and is often omitted (*pro-drop*) if it is a pronoun; it is understood from the verb endings, which show person and number [9]. The *direct object*, correspondingly, is in the accusative and can be replaced by the appropriate clitic. For the *indirect object*, the preposition "*se*" (forming a *se-NP*, Noun *Phrase*) is used with clitics and the accusative, or a genitive clitic, since the dative case is no longer used in Modern Greek. Also important is *clitic doubling*, the co-occurrence of a pronoun and a noun phrase with the same referent. This serves functions of clarification, emphasis, and focus.

We see the corresponding examples (1), (2), (3), and (4) below (Table 1):

Table 1. *Examples of sentences*

(1)	**Egrapsa**	**gramma**	**se enan filo**
	wrote	**a letter**	**to a friend**
	I wrote a letter to a friend.		
	P	**2**	**3**
	pro-drop 1, 1=ego – I (unpronounced)		

(2)	**O daskalos**	**elise**	**tin askisi**	**stous mathites**
	The teacher	**solved**	**the exercise**	**for the students**
	The teacher solved the exercise for the students.			
	1	**P**	**2**	**3**

(3)	**Tou**	**to**	**edosa**
	to him	**it**	**gave**
	I gave it to him.		
	3	**2**	**P**
	pro-drop 1, 1=ego – I (unpronounced)		

(4)	**O Giorgos**	**tin**	**agapise**	**tin Maria**
	George	**her**	**loved**	**Mary**
	George loved Maria.			
	1	**2**	**P**	**NP as clitic doubling**

Source: The authors.

In example (4) (Table 1), the *Noun Phrase* (*NP*) "*tin Maria*" can be analyzed as appositive rather than as a *second direct object*.

4.2 Passive Voice

The passive voice is a fundamental syntactic phenomenon in Greek. RG provides a clear and universal explanation of how the *direct object* of an active sentence *is promoted to subject* in the passive, while the original subject becomes a *Chômeur*. This dynamic change of relations is central to RG and accurately describes the Greek passive, as exemplified below (Table 2 and Table 3).

Table 2. *Initial Stratum – Active Voice*

O Giannis	**edose**	**sto paidi**	**to vivlio**
John	**gave**	**to the child**	**the book**
John gave the book to the child.			
1	**P**	**3**	**2**

Source: The authors.

The original direct object "*to vivlio*" (Table 2: 2) is promoted to *subject* (Table 3: 1). The SUL tells us that there cannot be two subjects, so the original subject "*O Giannis*" (Table 2: 1) loses its position and becomes a *chômeur*, expressed with the preposition "*apo*" (Table 3: 1-chômeur). The indirect object "*sto paidi*" (Table 2: 3) is not affected, since there is no conflict of grammatical relations. It remains (Table 3: 3) in the passive sentence.

Table 3. *Final Stratum – Passive Voice*

To vivlio	**dothike**	**sto paidi**	**apo ton Gianni**
The book	**was given**	**to the child**	**by John**
The book was given to the child by John.			
1(final 1, 2→1)	**P**	**3**	**1-chômeur**= apo ton Gianni (agent)

Source: The authors.

In English, the situation is a bit different. When there are two objects (direct and indirect), there are two possible transformations into the passive voice. In the following example (5a), (5b), and (5c), we can see these transformations (Table 4):

Table 4. *Transformations into the passive voice*

(5a)

John	**gave**	**a gift**	**to Mary**
1 (agent)	**P**	**3** (theme)	**2** (recipient)

(5b)

A gift	**was given**	**to Mary**	**(by John)**
1	**P**	**3**	**chômeur**

(5c)

Mary	**was given**	**a gift**	**(by John)**
1	**P**	**2**	**chômeur**

Source: The authors.

In RG, the phenomenon of *Dative Passive* is defined as the "promotion of the indirect object to the subject position". The idea is that an *indirect object* in the *dative* can be "promoted" to the subject of a passive sentence, as in example (5c, Table 4)). In *Modern Greek*, however, the dative case no longer exists as an independent morphological category. Because of this, "pure" Dative Passives do not occur in the contemporary language [10].

Verbs such as "*didasko*" (teach), "*mathaino*" (learn), and "*kerno*" (treat) allow a double passive voice, as in the examples (6a), (6b), and (6c) below (Table 5):

Table 5. *Double passive voice*

(6a)

Disasko	**ston Gianni**	**ti grammatiki**
teach	**(to) John**	**(the) grammar**
I teach John grammar.		
P	**3**	**2**
pro-drop 1, 1=ego - I (unpronounced)		

(6b)

I grammatiki	**didahtike**	**ston Gianni**	**(apo emena)**
(The) Grammar	**was taught**	**to John**	**(by me)**
Grammar was taught to John (by me).			
1	**P**	**3**	**chômeur**
Promotion **2 → 1** και **1 → chômeur** it is implied			

(6c)

O Giannis	**didahtike**	**ti grammatiki**	**(apo emena)**
John	**was taught**	**(the) grammar**	**(by me)**
John was taught grammar (by me).			
1	**P**	**2**	**chômeur**
Promotion **3 → 1** και **1 → chômeur** it is implied			

Source: The authors.

4.3 Unaccusative Hypothesis - UH

The *Unaccusative Hypothesis*, a theory proposed by David Perlmutter in 1978, divides intransitive verbs into two subsets: *unaccusative* and *unergative*. Unaccusative verbs are those whose grammatical subject is not the semantic agent of the action. In simple terms, the subject does not actively initiate or is not responsible for the event expressed by the verb; semantically, it is a *patient* or a *theme*. That is, the subject of an unaccusative verb is similar to the *direct object* of a transitive verb or to the *subject of a passive verb*. In contrast, *unergative verbs* describe actions that are initiated *voluntarily* by the subject, whose role is semantically that of an *Agent* [11].

The distinction between unaccusative and unergative verbs is fundamentally semantic, based on whether the single argument is an Agent (unergative) or a Patient/Theme (unaccusative). This is closely connected to the *Universal Alignment Hypothesis*, which claims that semantic roles predict the initial grammatical relations.

The Unaccusative Hypothesis argues that the single argument of unaccusative verbs originates as an *internal argument* (like an object) and later moves to the subject position. This contrasts with unergative verbs, whose single argument is a subject at all levels of representation.

As an example, we can mention the sentence "*O kathreptis espase*" ("*The mirror broke*"), where below (Table 6) we see in stratum C1 the *underlying structure*, while in stratum C2 the *surface structure*. That is, we have a promotion from (*initial*) 2 → (*final*) 1.

Table 6. Unaccusative verbs
Stratum C1 (Hypothetical, Original structure):

Kapoios	**espase**	**ton kathrepti**
Someone	**broke**	**the mirror**
1 - Impersonal/unspecified Agent (e.g., "**kapoios-someone**", "**kati-something**")	**P -** Active, though not overt	**2 -** The thing that is affected

Stratum C2 (Final structure):

O kathreptis	**espase**
The mirror	**broke**
1 - The initial 2 is promoted to 1	**P -** The verb takes a passive/middle voice form

Source: The authors.

The initial 1 is not expressed and does not become a *Chômeur*, since it is not necessary to be specified. The single term *starts as an object* and *is promoted to a subject* in order to satisfy the SUL and the UAH.

4.4 Clause Union - CU

The *ascension rule* in RG refers to the process by which a term (e.g., a noun phrase) from an *embedded clause* is "raised" and assumes a grammatical relation in the *main clause*. In RG, there are two main types of raising [12], [13]:

(i) *Subject-to-Subject Raising - SSR*: It occurs when the subject of an embedded clause becomes the subject of the main clause:

- *Fainetai oti* ***o Giannis*** *einai arrostos – It seems that* ***John*** *is sick* ("*O Giannis*" is the subject of the clause "*oti o Giannis einai arrostos*").
- ***O Giannis*** *fainetai na einai arrostos -* ***John*** *seems to be sick* ("*O Giannis*" becomes the subject of "*fainetai*").

(ii) *Subject-to-Object Raising - SOR***:** It occurs when the subject of an embedded clause becomes the object of the main clause. This phenomenon is more common in other languages (e.g., English) with verbs such as *believe* or *prove*:

- *Pisteuo oti* ***autos*** *einai timios - I believe that* ***he*** *is honest* (Subject of the subordinate clause).
- ***Ton*** *pisteuo timio - I believe* ***him*** *to be honest* (Object of the main clause).

In RG, *Clause Union* describes a process in which the *grammatical relations* (e.g., Subject, Object) of the embedded clause are transferred to the main clause. As a result, a single clause is formed where the original terms (Subject, Object) of the embedded clause take on new, different relations in the main clause. Clause Union is one of the mechanisms by which Relational Grammar explains the complex structure of *causative verbs* in various languages, showing how a two-clause structure can have the surface form of a single clause.

5 Python Implementation of Relational Grammar for the Greek Language

The implementation of Relational Grammar is done using *Python* [14], [15]. The program analyzes sentences of Modern Greek and assigns RG roles [16]: P (predicate), 1 (subject), 2 (direct object), 3 (indirect object), and *1-chômeur*. It is based on the *spaCy* library (with the pre-trained Greek pipeline *el_core_news_lg*) and on heuristics that correct common errors of syntactic parsing. The spaCy library does not directly "understand" RG notions, but its ability to perform accurate syntactic analysis makes it a powerful tool for exploring and representing the grammatical relations described by RG theory.

This library returns a *dependency parse* using labels from the *Universal Dependencies* (UD) framework, such as *nsubj*, *obj*, *iobj*, *obl*, etc. [17], [18], [19]. However, RG is not based on *dependencies* but on *syntactic relations* that result from transformations. This is where the *heuristic rules* come in: they "bridge" spaCy's analysis with the theoretical RG model. In other words, these are *mapping rules* that allow us to convert spaCy's output (dependency labels & morphological features) into RG relations, together with the possible transformations (advancements, demotions, etc.).

The mapping of UD to RG is a complex issue, as the two frameworks are based on different philosophies. UD focuses on the *surface structure* of the sentence and the dependency relations between words, while RG analyzes the *syntactic roles* (e.g., Subject, Object) across *multiple levels* (*strata*), from the underlying to the surface.

Specifically, if there is the label *nsubj*, it corresponds to 1 (subject). If it is absent and a pronoun is implied (pro-drop), the subject is inferred based on the verb's morphology (use of Universal Features-UFeats, mostly person, number). In the passive voice, for *nsubj: pass,* we have a 2→1 *promotion* (*advancement*), i.e., an object that has become the subject. If there is *obj* or clitics in the accusative, or a Noun Phrase (NP) after the verb, they correspond to 2 (direct object). For 3 (indirect object) we check for *iobj*, or alternatively genitive clitics, or *obl* with the preposition "*se*". The distinction from adverbial complements is sometimes ambiguous because "*se*" produces an *obl* dependency that UD cannot distinguish between an indirect object (3) and

an oblique adjunct (N), The solution is to disambiguate by using the verb's valency (ditransitivity) and object co-occurrence. The labels ROOT and *cop*, which are used in identifying *P*, indicate the *main verb* of the sentence, respectively, and the link of the *predicate* to a *copular verb*. Certain verbs require a *subcategorization dictionary* for accurate recognition. Finally, for *1-chômeur* (*cho*) we look for the label *obl:agent* or a PP with the preposition "*apo*" in the passive voice.

For convenience, a set of sentences was created to represent the most typical cases, and with the help of a test file, all the sentences were automatically checked each time the main file was modified. Besides spaCy, the Stanza (Stanford NLP) library can also be used, which provides better results but is slower.

6 Conclusion

Relational Grammar distinguishes itself by focusing on the independence of grammatical relations from the phrasal status of terms and by making subject–object relations fundamental to syntactic analysis, rather than treating these relations as derived from phrasal structure.

Because grammatical relations are considered universal in RG, it allows linguists to easily compare syntactic phenomena in Greek with those of other languages, highlighting both common principles and language-specific features. Through this, a framework was produced for their comparison and analysis. Although it did not become the dominant theory in linguistics, it influenced other theoretical approaches, such as *Lexical-Functional Grammar* (LFG), by incorporating more mechanisms for handling syntactic structures, and *Role and Reference Grammar* (RRG).

In conclusion, Relational Grammar offers a robust and coherent framework for analyzing the syntactic structure of the Greek language. By focusing on the dynamic changes of grammatical relations across strata, RG provides a tool for understanding the passive voice and other complex phenomena. Despite its challenges, RG remains an important contribution to linguistic theory and can shed light on aspects of Greek syntax that other theories may not highlight in the same way.

Future research directions plan to further explore Relational Grammar in applications for the Greek language, focused on Natural Language Processing (NLP) and Natural Language Understanding (NLU). In this context, a combination of RG and Link Grammar is tested for Modern Greek [20], while the case of its integration into an intelligent Human-Robot Interface (iHRI) for robotic applications, such as the use of speech exchange with vehicles for operational usage [21], is examined. It is expected that the features of RG will improve the dialogue handling capabilities and increase the intelligibility index of the resulting systems.

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George V. Chorozoglou designed the algorithms and wrote the text.
Ioannis Giachos carried out the simulation and the optimization.
Evangelos Papakitsos has organized and executed the experiments.
Nikolaos Zacharis assessed the methodology and supervised the project.

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