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THE DIACHRONIC DEVELOPMENT OF LINGUISTIC COMPLEXITY: EVIDENCE FROM THE DIACHRONY OF ANTICAUSATIVES IN GREEK

In the present study, our aim is to investigate how different approaches to morphosyntactic complexity lead to different conclusions on the diachronic development of complexity. We propose two distinct types of complexity: *structural* and *dynamic complexity*. Structural complexity is divided into parametric complexity and complexity of derivation, and dynamic complexity is defined as the combination of struxtural complexity with the probability/information content of a construction per time unit. We examine the diachrony of voice morphology in Greek, focusing particularly on anticausative verbs. We argue that the two types of complexity demonstrate a different type of diachronic development, albeit rather predictably: structural complexity of anticausatives increased by the time this class of verbs could be found with both active and nonactive morphology (Koine Greek) and as a by-product of the parametric changes that voice morphology underwent. Conversely, dynamic complexity traced a circular path: its level at different period was affected both by structural complexity and by the probability of the old (nonactive) and the new (active) class of anticausatives.

Keywords: diachronic complexity, Greek anticausatives, voice morphology

1. INTRODUCTION

1.1. Complexity

The classical definition of complexity is based on the notion of "Kolmogorov complexity" (Kolmogorov 1965): "[The complexity of an object is] measured by the length of the shortest description of that object" (Dahl 2004: 40, among many others). However, in recent decades, factors such as processing, acquisition and learning have been included in the analysis of complexity (Trudgill 2009, 2011; Joseph & Newmeyer 2012, among many others).

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The "metrics" of complexity have been linked to various parameters. For instance, McWhorter (2002, 2011) proposes that the following parameters can be used for a comparison of complexity of grammars: (i) irregularity, (ii) overspecification, and (iii) structural elaboration (the surface forms are linked to the underlying ones through a rich number of rules).

There is consensus that tendencies toward simplification, rather than tendencies toward complexification, are at the center of language change. The main reason for the above conclusion is that both external factors of change, for instance, contact, and internal factors of change, for instance, economy, are related to simplification (van Gelderen 2004, among many others).

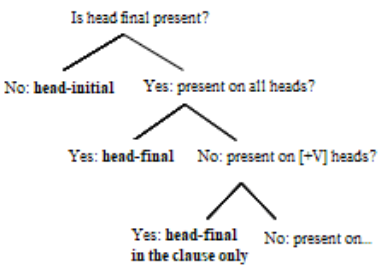
1.2. The idea of split complexity

Di Sciullo (2012) proposes a distinction between internal complexity (I-complexity) and external complexity (E-complexity). I-complexity correlates to morphological and syntactic derivation and their operations, whereas E-complexity is related to frequency. For Di Sciullo, I-complexity concerns the complexity of operations in the language faculty, and E-complexity concerns occurrences in corpora and surface characteristics of morphologies.

Lavidas (2018) proposes that I-complexity should be split into parametric-I-complexity (p-I-complexity) and derivational-I-complexity (d-I-complexity). D-I-complexity is similar to the type of I-complexity proposed by Di Sciullo. P-I-complexity is based on parametric routes proposed by Bickerton (1984) and an analysis of parameters suggested in a series of papers by Biberauer et al. Complex routes of parameters and learning patterns lead to p-I-complexity. Accordingly, some parametric routes can be complex and other parametric routes simpler. A type of a hierarchy can represent the parameters (see 1), where lower options are more complex (Biberauer et al. 2014). In other words, grammars lower in a hierarchy may apply even to lexical items.

(1)

Hierarchy: Word Order. From Biberauer et al. (2014: 110), based on Roberts (2012)



Higher parametric options are historically more stable than lower parametric options of a given hierarchy (Biberauer & Roberts 2012; Branigan 2012). The list in (2) outlines the generalizations related to parameters and change as suggested by Biberauer & Roberts (2012) and Biberauer et al. (2014).

(2) a. Macroparameters (the highest parametric options): stable over millennia
b. Mesoparameters: somewhat stable
c. Microparameters: somewhat unstable
d. Nanoparameters (the lowest parametric options): highly unstable
(Biberauer & Roberts 2012; Biberauer et al. 2014)

Hence, on the one hand, nano- or microparametric options are "further along a given learning path" (Biberauer et al. 2014: 115); however, they involve more frequent elements. In addition, high frequency leads to simpler grammars in terms of E-complexity.

2. GREEK ANTICAUSATIVES

2.1. Introduction

Many studies have shown that voice morphology of Greek is one of the most diachronically unstable domains of Greek. For instance, the diachrony of Voice in Greek evidences a clear reorganization of voice morphology and change in Voice in the history of Greek can be analyzed as a tendency toward increasing complexity.

Modern Greek anticausatives (unaccusatives with a causative counterpart) are marked with (i) active voice morphology (e.g., *eklise* 'closed'), (ii) both active and nonactive voice morphology (voice morphology alternation – e.g., *lerose*/ *lerothike* 'got dirtied'), and (iii) nonactive morphology (e.g., *miothike* 'reduced'). In contrast, anticausatives are morphologically a single verbal class in pre-Koine Greek, where all are marked with nonactive (middle/passive) voice morphology. Auto-benefactive transitives, passives and reflexives are also marked with nonactive voice morphology in the pre-Koine periods.[2] This means that, in pre-Koine periods, the nonactive (middle/passive) voice morphology marks all types of valency-reducing derivations. Therefore, it marks all classes of anticausatives because no agent is implied with anticausatives. In post-Koine periods, nonactive voice morphology marks one class of anticausatives only, and it does not mark auto-benefactive transitives. The active voice morphology marks most of the anticausatives, which leads to lability: the verb is marked with the same

[2] Deponents do not show transitivity alternation, and therefore, we do not include them in our study (on deponents and their development, see Lavidas & Papangeli 2007).

(active) voice morphology when used both in the causative and anticausative constructions. Lability, as seen in (3a-b), can result in ambiguity, processing difficulties and increased complexity.

(3) a. Active causative
(i texnologia) alakse to topio tis ergasias
(art.nom technology.nom) change.act.pst.pfv.3sg art.acc scenery.acc art.gen work.gen
'(Technology) changed the scenery of work/ work life.'
b. Active anticausative
alakse to topio tis ergasias
change.act.pst.pfv.3sg art.nom scenery.nom art.gen work.gen
'The scenery of work/ work life changed.'

2.2. Evidence from the Greek diachrony

In Ancient Greek, non active voice morphology marks anticausatives, whereas active morphology marks internally caused changes of state anticausatives. Very few anticausatives are attested with both active and nonactive (middle/passive) morphology in different contexts. The absence of anticausatives attested only with active morphology in Ancient Greek texts constitutes the most significant difference between the voice morphology of Ancient Greek and the post-Koine periods (Lavidas 2009).

Anticausatives of post-Koine Greek marked consistently with active morphology are attested with nonactive (middle/passive) voice morphology in Ancient Greek. Koine and post-Koine Greek demonstrate a clear tendency for marking all anticausatives with active morphology, which results in three classes of anticausatives: (i) the "new" class of active anticausatives, (ii) the class of anticausatives marked either with active or nonactive morphology (reflecting a transitional period), and (iii) the "old" class of nonactive anticausatives.

The "new" organization of the Voice system results in contrasting anticausatives morphologically with passives, which also participate in transitivity alternations: the "new" system requires that the nonactive voice morphology is present only when an (implied) agent is present. In addition, the nonactive morphology cannot have an auto-benefactive interpretation – in contrast to pre-Koine Greek.

All periods of post-Koine Greek demonstrate the spread of active morphology to more anticausatives. In Modern Greek, active morphology marks both internally- and externally-caused change of state anticausatives: e.g., *sapizo* 'rot' – *spao* 'break'. Voice (active and nonactive) alternating anticausatives and the small class of nonactive anticausative include externally-caused change

of state anticausatives only: e.g., *katharistike/katharise* 'cleaned' – *afksithike* 'increased'. The above observations show a clear path of spread of the active voice morphology marking anticausatives: from internally-caused change of state, to externally-caused change of state. However, the change has not yet affected a small number of externally-caused change of state verbs (see Lavidas 2018 on the role of prescriptivism in delaying morpho-syntactic change).

3. MEASURING DIACHRONIC COMPLEXITY

According to Lavidas (2018), diachronic complexity of syntax can be split into two subtypes:

(i) Parametric complexity (p-I-complexity)

(ii) Complexity of derivation (d-I-complexity)

For the estimation of *p-I-complexity*, we assigned a probability to each parameter according to its position in the parameter hierarchy, following Biberauer et al. (2014); the complexity associated with each position was defined as the inverse of each probability (1/0.5^n). For the calculation of *d-I-complexity*, we devised a simple model that employs the notion of vertex degree and combines it with knowledge about structural complexity. We assigned different weights to the edges of a syntactic tree based on what type of merge they denote, following Rizzi's (2016) hierarchy of combinatorial systems. According to Rizzi (2016: 143–144), systems that allow different types of merging are arranged in a hierarchy of complexity depending on their generative capacity and the computational resources required. For a discussion of the possible neurological implementations of different types of Merge, see Johansson (2020). Lexical items were given a weight of 1. Merging of two lexical items (1-Merge, following Rizzi [2016]) was, then, given a weight of 2. Merging a phrase with a lexical item (2-Merge) was given a weight of 3 because 2-Merge is produced by combining the output of 1-Merge (= 2) with a lexical item (= 1). Accordingly, 3-Merge (or phrase-to-phrase merge), being the most complex of all types, was construed as the product of two successive 2-Merge operations (2 + 2).[3]

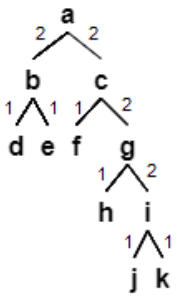
Overall, the vertex degree of a node was defined as the weight sum of the two edges leading to it. This is illustrated in (4). In this example, *a* is a product of 3-Merge and has a vertex degree of 4; it is built by combining the products of two 2-Merge operations represented by two edges with a weight 2 each. Nodes *c* and *g* are products of 2-Merge and have a vertex degree of 3; they are built by combining a phrase (2-Merge) with a lexical item (1-Merge) represented by two edges of weights 2 and 1, respectively. Nodes *b* and *i* are products of 1-Merge and

[3] See also Uriagereka (et al's) discussion of complexity in several publications: for instance, cf. Uriagereka et al. 2013.

have a vertex degree of 2; they are built by combining two 1-Merge operations represented by two edges of weight 1 each. Finally, the rest of the nodes in (4) are lexical items and are given a weight of 1.

In order to estimate the complexity of a derivation, we calculated the vertex degree of each syntactic node in the syntactic tree, counting only the number of edges below each node. Thus, the complexity of a syntactic tree is defined as the vertex degree sum of all its nodes. In the case of (4), the vertex degree sum is 14.

(4)



In *Information Theory* (Shannon 1948), the average amount of uncertainty associated with a variable is known as *Entropy*. A related metric to Entropy is *Perplexity* (defined as 2^Entropy). To say that a system's perplexity is *n* at a given point *t* means that to predict the outcome of a variable at this point is so complex as if having to choose between *n* equiprobable outcomes. When there are two possible outcomes, Perplexity takes values between 1 and 2 (Ackermann & Malouf 2013). Evidently, the system of Greek anticausatives has maximal Perplexity at the point where both types of anticausatives (active and nonactive) are equally productive. When one verb form (active or nonactive) prevails, perplexity is reduced, as the information content of the system decreases.

We suggest that the interaction of structural properties with the perplexity of a system at a given time conditions the diachronic development of complexity of a linguistic (sub-)system. Therefore, we postulate the *hypothesis of dynamic complexity*, according to which, changes in the information content of a system undergoing change interact with changes in derivation and parametrization in such a way that the former may balance the effect of the latter (see Symeonidis 2020). Thus, we define the dynamic complexity of a system to be equal to d-I- and p-I-complexity multiplied by the level of Perplexity at any time unit.[4] The reasoning behind the above definition is the following: Perplexity captures how informative

[4] For a different definition of dynamic complexity, based on type frequency rather than information content, see Symeonidis & Lavidas (2023).

(complex) the system of anticausatives is in terms of how well a 2-class categorical distinction can describe it. For instance, when perplexity is equal to 1.9, this means that the distribution of probabilities of the two verb classes (active and nonactive) is almost as even as in a system of two equiprobable classes, whereas a perplexity of 1.2 shows that their probabilities are more uneven making the system a less good example of a 2-category system. In other words, although we can identify two categorical classes of anticausative verbs in most stages of Greek, the complexity of the system at each stage differs based on how well it exemplifies a 2-class distinction system. Hence, the complexity of the system at different stages must be proportional to the information content it encapsulates at each respective stage.[5]

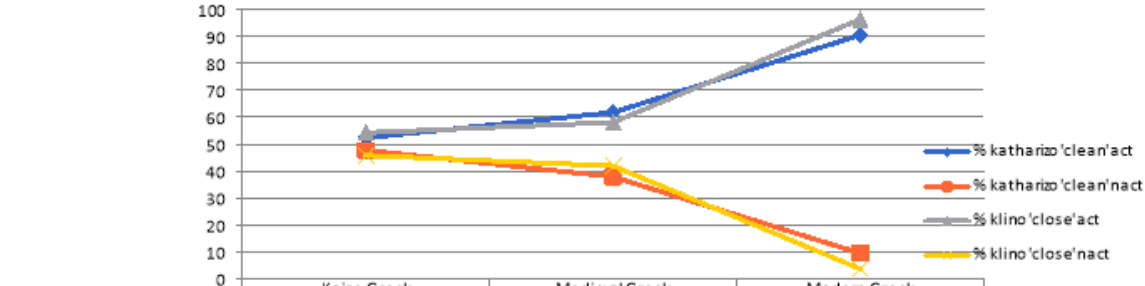
4. REMARKS ON A QUANTITATIVE ANALYSIS OF THE COMPLEXITY OF GREEK ANTICAUSATIVES

Figures 1 and 2 demonstrate that all verbal classes follow a similar development of the voice morphology of anticausatives – regardless of their lexical conceptual structure (on Lexical Conceptual Structure, see Jackendoff [2002], among many others).[6] Lavidas et al. (2012) investigated the development of the voice morphology of the verbs *liono* 'melt', *sapizo* 'rot', *vrazo* 'boil', *stegnono* 'dry', *klino* 'close' (anticausatives bearing active morphology in Modern Greek), and *katharizo* 'clean' (anticausative showing morphological alternation between active and nonactive in Modern Greek). Note that *klino* 'close' and *katharizo* 'clean' are externally-caused change of state verbs (two-place predicates) – in contrast to the other verbs of the list. The conclusion of Lavidas et al. (2012) is that both Modern Greek anticausatives bearing active morphology and Modern Greek anticausatives bearing active and nonactive morphology were marked with nonactive morphology in Ancient Greek, the active morphology being a later change. All verbs on the list favor active voice morphology for anticausative readings in Modern Greek; however, earlier post-Koine periods demonstrate important differences. E.g., *stegnono* 'dry', *vrazo* 'boil', *klino* 'close', and *katharizo* 'clean' evidence an increase in the active voice morphology in Medieval Greek, whereas *liono* 'melt' and *sapizo* 'rot' evidence a preference for nonactive in all

[5] Mathematically, the definition of dynamic complexity as *(d-I + p-I) X Perplexity* is equal to *(d-I + p-I) + Entropy*. Therefore, dynamic complexity can be conceived of as equal to the amount of derivation and parametric complexity of a grammatical system plus the amount of information entropy associated with it at each stage.

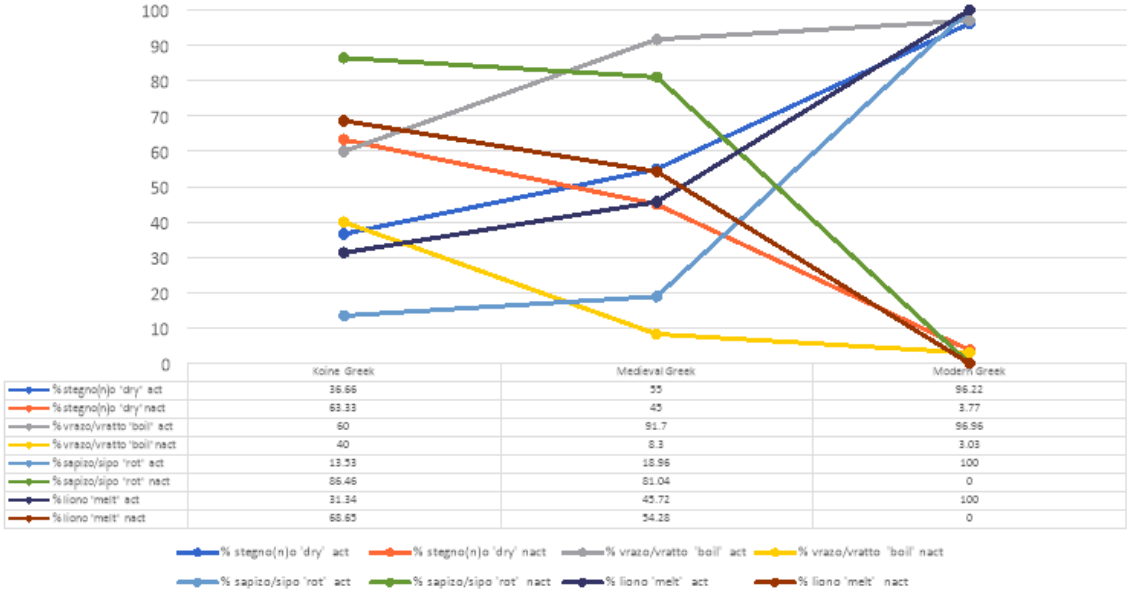
[6] Conceptual structure (CS) is the cognitive organization that thoughts expressed by language are structured. According to Jackendoff (2002: 123): "[C]onceptual structure is not a part of language per se – it is a part of thought. It is the locus for the understanding of linguistic utterances in context, incorporating pragmatic considerations and 'world knowledge'; it is cognitive structure in terms of which reasoning and planning take place."

pre-Modern Greek periods. Figure 3 also presents a contrast between *klino* 'close' and *katharizo* 'clean' and all other verbs.



	Koine Greek	Medieval Greek	Modern Greek
% katharizo 'clean' act	52.3	61.77	90.53
% katharizo 'clean' nact	47.69	37.86	9.46
% klino 'close' act	54.21	58.08	96.4
% klino 'close' nact	45.78	41.91	3.59

Figure 1. Change in active vs. nonactive morphology (%): anticausatives *katharizo* 'clean' and *klino* 'close' (from Lavidas et al. 2012: 394)



	Koine Greek	Medieval Greek	Modern Greek
% stegno(n)o 'dry' act	36.66	55	96.22
% stegno(n)o 'dry' nact	63.33	45	3.77
% vrazo/vratto 'boil' act	60	91.7	96.96
% vrazo/vratto 'boil' nact	40	8.3	3.03
% sapizo/sipo 'rot' act	13.53	18.96	100
% sapizo/sipo 'rot' nact	86.46	81.04	0
% liono 'melt' act	31.34	45.72	100
% liono 'melt' nact	68.65	54.28	0

Figure 2. Change in active vs. nonactive voice morphology (%): *stegnono* 'dry', *vrazo* 'boil' and *sapizo* 'rot' (from Lavidas et al. 2012: 394)

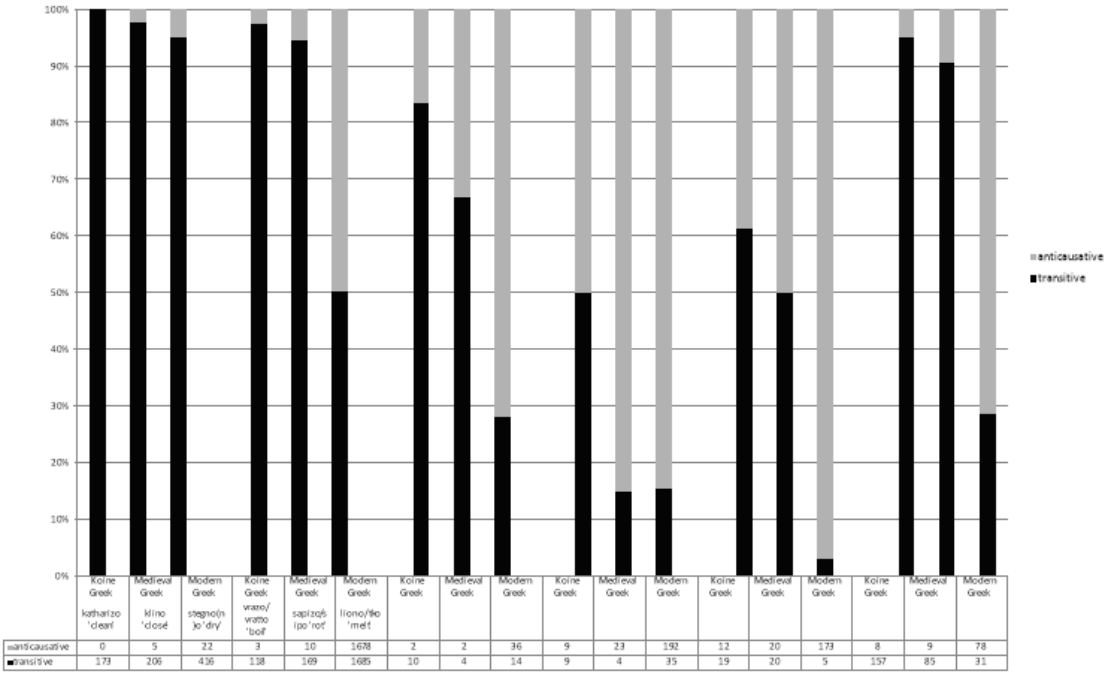


Figure 3. Change in active transitives vs. active anticausatives: analysis by verb (from Lavidas et al. 2012: 395)

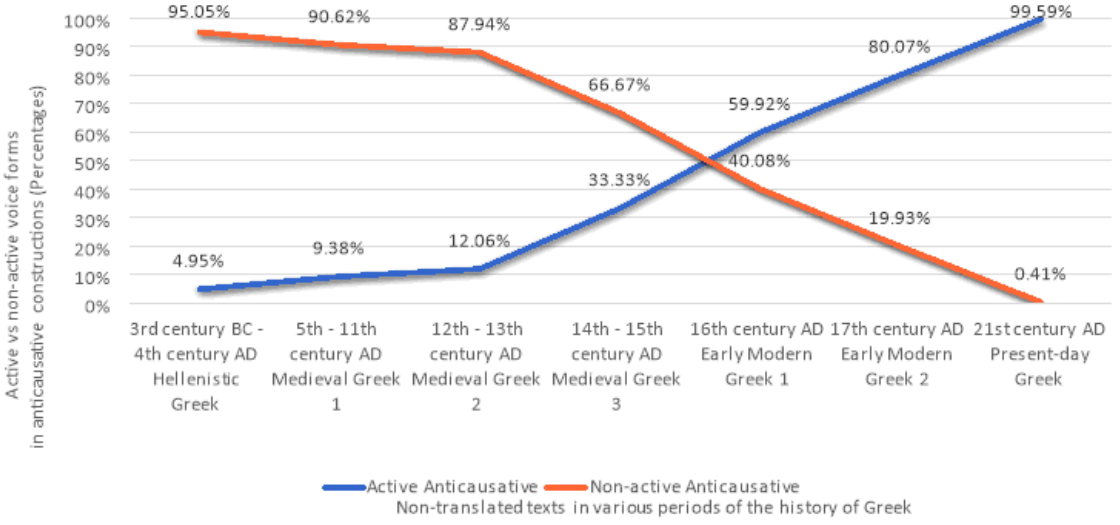


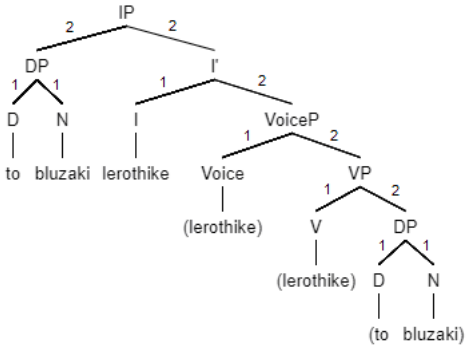
Figure 4. Distribution of voice morphology of verbs in anticausative constructions in the corpus of Greek translations of the New Testament. Word list: *katharizo* "clean", *klino* "close", *liono* "melt", *sapizo* "rot", *vrazo* "boil", *stegnono* "dry". Part of the data is based on data from Lavidas et al. (2012)

Figure 4 reveals that, in Ancient Greek, anticausatives take the "active" value with probability equal to 0, as all verbs on the word list are attested with nonactive morphology in anticausative constructions. In Ancient Greek, no anticausatives are found *only* with active morphology. In this case, the information content of the system is at its lowest. Whether an anticausative verb is marked with active or nonactive voice at this stage is perfectly predictable *(no uncertainty)*. At any intermediary stage, however, the uncertainty of the outcome is higher, as both verb forms (active and nonactive) are possible, albeit with different probabilities. As the system approaches a state where both verb forms occur with equal probability (p = 0.5), its information content increases. In the Early Modern Greek period, the uncertainty of the outcome has reached a maximum because both outcomes were very close to equiprobability.

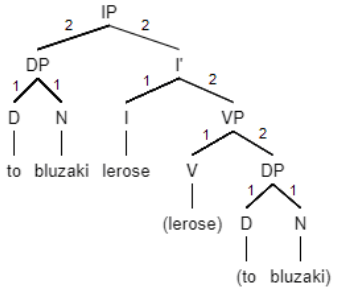
The diachronic complexity of (morpho-)syntax of Voice in Greek can be analyzed on the basis of the two types of I-complexity: (a) *p-I-complexity*: a microparameter is involved in the case of active anticausatives of post-Koine Greek, which are, therefore, complex to process and learn; (b) *d-I-complexity*: the derivation of active anticausatives does not require a Voice projection.

Anticausatives marked with active morphology are the simplest option in terms of derivation. This is exemplified in (5). The derivation of the sentence containing a nonactive anticausative, *lerothike*, is more complex (= 17) compared to the sentence containing an active anticausative, *lerose* (= 14), because the latter lacks a Voice projection.

(5) a.



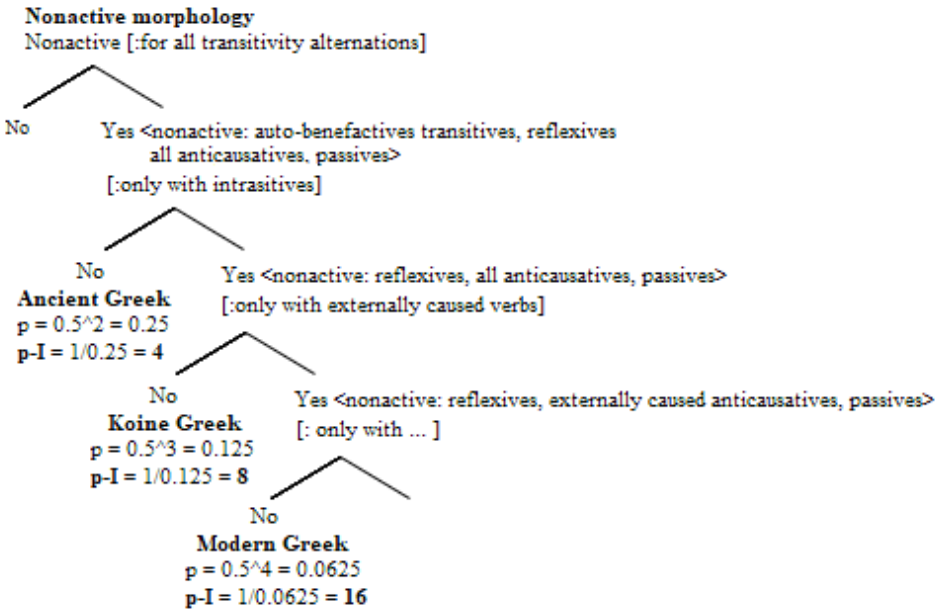
b.



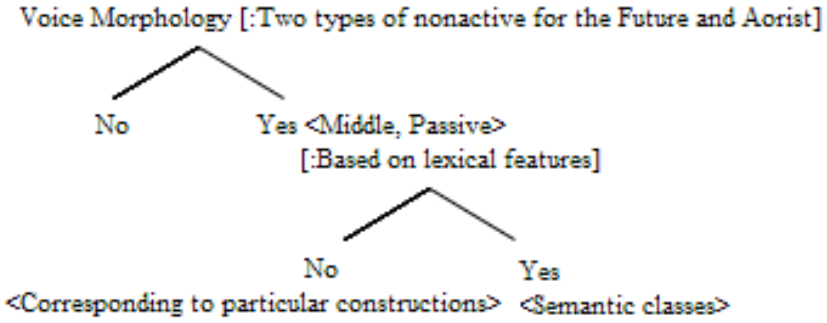
Evidently, intermediary stages of Greek, where both options are available, must be more complex because they employ both derivations. The complexity of the system at these stages is equal to the sum of the complexities of each derivation.

In contrast, (micro)parameters of active anticausatives are complex because they are lexically determined. Hierarchies in (6) and (7) concern the historical development of nonactive morphology and Voice in Greek (Lavidas 2018). The first parameter refers to nonactive morphology that marks any transitivity alternation through nonactive morphology. The second parameter requires that nonactive morphology marks intransitives only (nonactive auto-benefactive transitives are not available anymore). The third parametric option does not allow nonactive voice morphology with internally caused change-of-state anticausatives and can be seen as an example of a microparameter because it is lexically determined. Accordingly, one recognizes an overall tendency toward a system where nonactive morphology marks reflexives and passives only; all anticausatives are marked with active morphology.

The hierarchy of nonactive morphology presents Modern Greek as more complex than Ancient Greek in terms of p-I-complexity. Ancient Greek distinguishes morphologically between two types of nonactive morphology, middle and passive in the Aorist and Future, and therefore, is more complex than later Greek. In addition, the two morphologies of nonactive of Ancient Greek are difficult to acquire because they are lexically determined: Lexical (and morpho-phonological) features determine the verbs that can bear passive morphology only, the verbs that bear middle morphology only, and the verbs that can bear middle and passive morphology, in the Aorist and Future.



(6) Hierarchy I: Nonactive morphology



(7) Hierarchy II: Voice and Tense (from Lavidas 2018)

Our findings on diachronic complexity are summarized in Table 1 and plotted in Figure 5. In Koine Greek, d-I-complexity is equal to 31 (17 + 14) because both syntactic derivations (5a, b) are possible at this stage. P-I-complexity is equal to 1/(0.5^3) = 8 because of the position of Koine Greek in the hierarchy of parameters for nonactive morphology, as illustrated in (6). *Perplexity* is calculated based on the probability of each option occurring (active vs. nonactive anticausatives). Finally, *dynamic complexity* is defined as (d-I- + p-I-) X Perplexity and amounts to (31 + 8) X 1.22 = 47.58.

t	Stage	d-I-complexity	p-I-complexity	Perplexity	Dynamic complexity
1	Pre-Koine	17	4	1.00	**21.00**
2	Koine	31	8	1.22	**47.58**
3	Late Medieval	31	16	1.71	**80.30**
4	Early Modern	31	16	1.84	**86.48**
5	Present-Day	31	16	1.03	**48.41**

Table 1. The development of *d-I-*, *p-I-* and *dynamic complexity* of the anticausative verbs of Greek at 5 different periods. Perplexity reveals the information content of the system at each time unit. *Dynamic complexity* is defined as *(d-I + p-I) X Perplexity*

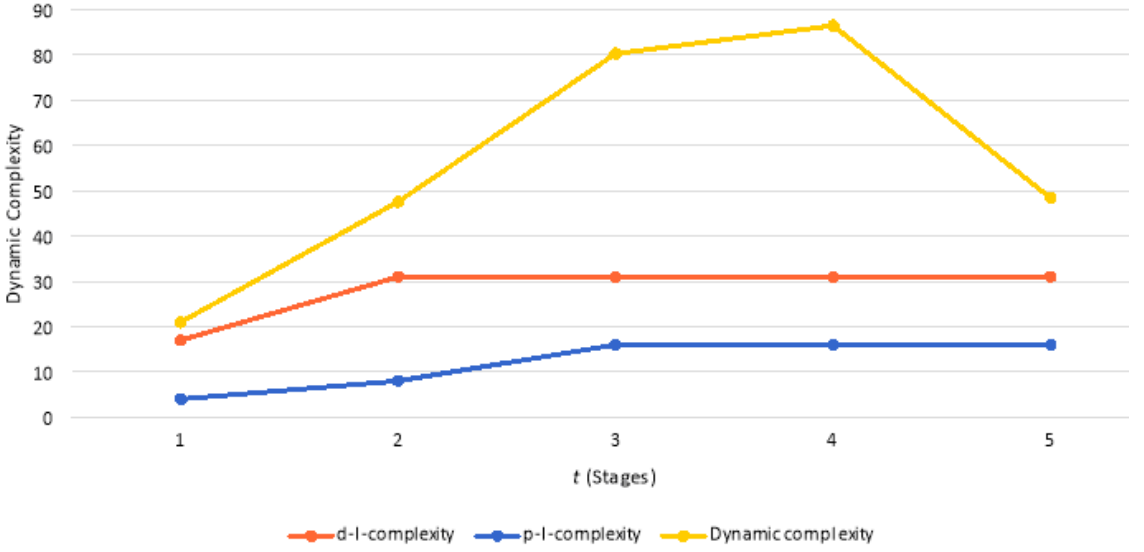


Figure 5. The development of *d-I*, *p-I* and *dynamic complexity* of the anticausatives verbs of Greek at 5 different periods

5. CONCLUSIONS

D-I-complexity increased in Koine-Greek due to the additional, new syntactic structure of active anticausatives and remained stable to the present day, as both active and nonactive anticausatives are available. P-I-complexity, however, increased in Late Medieval Greek due to the microparameter that determines the lexically constrained group of nonactive anticausatives.

Dynamic complexity (structural + information content) traces a circular path: Its level at different periods depends both on structural complexity (derivational and parametric) and on the probability of the old (nonactive) and the new (active) class of anticausatives. Specifically, dynamic complexity reaches a maximum in Early Modern Greek because (i) structural complexity is high and (ii) both classes are (almost) equiprobable. From that point on, it decreases because the class of active anticausatives gradually prevails.

In addition, even though syntactic complexity of anticausatives differs in Koine Greek and present-day Greek, dynamic complexity cancels out this difference. The cyclical development of dynamic complexity can be further understood as an indication of cyclical change in languages (van Gelderen 2011).

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Η ΔΙΑΧΡΟΝΙΚΗ ΕΞΕΛΙΞΗ ΤΗΣ ΓΛΩΣΣΙΚΗΣ ΠΟΛΥΠΛΟΚΟΤΗΤΑΣ: ΕΝΔΕΙΞΕΙΣ ΑΠΟ ΤΗ ΔΙΑΧΡΟΝΙΑ ΤΩΝ ΑΝΤΙΜΕΤΑΒΙΒΑΣΤΙΚΩΝ ΤΗΣ ΕΛΛΗΝΙΚΗΣ

Περίληψη

Στόχος της παρούσας εργασίας είναι να διερευνηθεί πώς διαφορετικές θεωρητικές προσεγγίσεις της μορφοσυντακτικής πολυπλοκότητας οδηγούν σε διαφορετικές προβλέψεις σχετικά με τη διαχρονική εξέλιξή της. Προτείνουμε δύο διακριτούς τύπους γραμματικής πολυπλοκότητας: τη δομική και τη δυναμική πολυπλοκότητα. Η δομική πολυπλοκότητα διαιρείται σε παραμετρική πολυπλοκότητα και πολυπλοκότητα παραγωγής, ενώ η δυναμική πολυπλοκότητα ορίζεται ως ο συνδυασμός της δομικής πολυπλοκότητας με τη συχνότητα και το πληροφοριακό φορτείο μιας δομής ανά μονάδα χρόνου. Αντικείμενο μελέτης μας είναι η μορφολογία της φωνής στη διαχρονία της Ελληνική, εστιάζοντας κυρίως στην ομάδα των αντιμεταβιβαστικών ρημάτων. Σύμφωνα με την υπόθεση εργασίας μας οι δύο τύποι πολυπλοκότητας αντικατοπτρίζουν διαφορετικούς τύπους αλλαγής. Συγκεκριμένα, η δομική πολυπλοκότητα των αντιμεταβιβαστικών ρημάτων διέγραψε ανοδική πορεία την περίοδο που αυτή η ομάδα ρημάτων ήταν συμβατή τόσο με την ενεργητική όσο και με την μη-ενεργητική μορφολογία (Κοινή Ελληνιστική), και ως συνέπεια των παραμετρικών αλλαγών του συστήματος της φωνής. Αντιθέτως, η δυναμική πολυπλοκότητα διέγραψε κυκλική πορεία: η τιμή της σε διαφορετικές περιόδους επηρεάστηκε τόσο από τη δομική πολυπλοκότητα όσο και από την συχνότητα της παλιάς (μεσοπαθητικής) και νέας (ενεργητικής) τάξης αντιμεταβιβαστικών.

Λέξεις-κλειδιά: διαχρονική πολυπλοκότητα, αντιμεταβιβαστικά ρήματα της Ελληνικής, μορφολογία φωνής