

# Parsing Greek morphology

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... in multiple dialects and alphabets

# Digital scholarship and Classics

- 25 years ago: a leading discipline
- today: largely absent from new areas of textual analysis?

## Example: latent pattern recognition

- topic modelling
- semantic relations with embedded word vectors

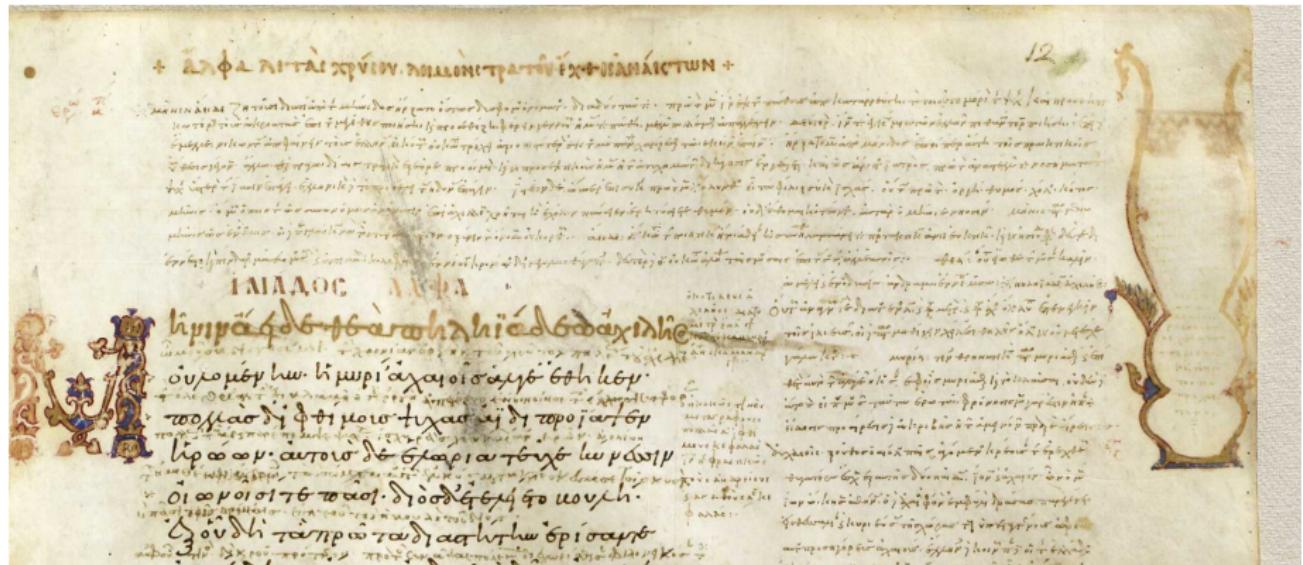
## Some reasons, good and bad

- corpus size vs. tolerance for imprecise editions
- morphological complexity

# Motivation

Homer Multitext project: manuscripts with

- multiple dialects
- unattested vocabulary
- distinct orthographies



## Current standards

- ISO 639\* family: Greek dialects not recognized
- Unicode:
  - language and script conflated
  - epichoric scripts not recognized
  - confusion of multivalent and contradictory glyphs

*In 2017, it is (still!) not possible to encode Greek*



Figure 2: A Vienna secession?

# Secession, 1

Encode Greek in a *specified orthography*, including :

- encoding in (primarily) ASCII characters with distinct character for accent, breathing
- encoding in (primarily) Greek Unicode suitable for display

# Encoding Greek

Literary Greek:

*ἔδοξε == e)/doce*

Pure diplomatic rendering of classical Attic:

*εδοχσεν == EDOXSEN*

Editorially normalized version of classical Attic:

*ἔδοχσεν τέι βολέι == E)/DOXSEN TE=I BOLE=I*

## Secession, 2

For historical languages, every analysis is corpus-specific

## A corpus-linguistic perspective

Every corpus is characterized by:

- a unique lexicon in a specified orthography
- a unique set of inflectional rules in a specified orthography

So not *a parser*, but...

*a system for building corpus-specific parsers*

## Citable results

- each lexicon entry has a unique ID for *lexical entity*
- each inflectional has a unique ID

## “Greek” is defined by *analytical categories*

- “noun” (GCN)
- “adjective” (GCND)
- “conjugated verb” (PNTMV)
- “infinitive” (TV)
- “participle” (GCTMV)
- “verbal adjective” (GCN)
- “adverb” (Degree)
- “indeclinable” (part of speech)

## An analysis is composed of

- a string of characters analyzed
- a form
- a uniquely identified lexical entity
- a uniquely identified inflectional rule

# Kanónes

A system for building parsers from tables defining:

- ① inflectional rules
- ② a lexicon of “stems”

# Parsing morphology

- standard technology: finite state transducers (FST)
- require context-free state transitions

# Parsing Greek

FSTs fail!

*Crossing of lexical and inflectional properties of accent cannot be reduced to context-free state transitions*

# Solution in Kanónes

“Analysis by synthesis” algorithm:

- ① collect an accented word
- ② strip its accents, and use FST to get *possible* analyses
- ③ algorithmically apply correct accent
- ④ compare accented candidate forms to original word

## Example parse

- ① original word: εἰπε
- ② εἰπε analyzed as:
  - 3rd singular aorist indicative active
  - 2nd singular aorist imperative active
- ③ accenting yields:
  - εἰπε for 3rd singular aorist indicative active
  - εἰπέ for 2nd singular aorist imperative active
- ④ so solution is 3rd singular aorist indicative active

## A simple worked example: two parallel corpora

Andocides *On the Mysteries* 1.96

Νόμος. ἔδοξε τῇ βουλῇ καὶ τῷ δῆμῳ.

IG 1.3, 156



Figure 3: Decree honoring Leonides of Halicarnassus

## Vocabulary (“stems”)

1	ID	Lexical entity	Stem	Gender	Inflection class	Accent class	Notes
2	vienna.att1_0	lexent.n1	BOL	fem	h_hs	inflacc	βολέ
3	vienna.att2_0	lexent.n2	DEM	masc	os_ou	stemacc	δῆμος

Figure 4: Nouns, in Attic

1	ID	Lexical entity	Stem	Gender	Inflection class	Accent	Notes
2	vienna.n1_0	lexent.n1	boul	fem	h_hs	inflacc	βουλή
3	vienna.n2_0	lexent.n2	dhm	masc	os_ou	stemacc	δῆμος
4	vienna.n4_0	lexent.n4	nom	masc	os_ou	stemcc	νόμος

Figure 5: Nouns, in literary Greek

## Inflectional rules

1	Rule	Inflection class	Ending	Gender	Case	Number
2	attnouninfl.h_hs3	h_hs	EI	fem	dat	sg
3	attnouninfl.os_ou3m	os_ou	OI	masc	dat	sg

Figure 6: Nouns, in Attic

1	Rule	Inflection class	Ending	Gender	Case	Number
2	nouninfl.h_hs3	h_hs	h	fem	dat	sg
3	nouninfl.os_ou1m	os_ou	os	masc	nom	sg
4	nouninfl.os_ou3m	os_ou	w	masc	dat	sg

Figure 7: Nouns, in literary Greek

# Analysis

- ✓ νόμος analyzed as noun, masculine, nominative, singular, from lexent.n6
- ✓ ἔδοξε analyzed as verb, third, singular, aorist, indicative, active, from lexent.n3
- ✓ τῇ analyzed as adjective, feminine, dative, singular, no degree, from lexent.n4
- ✓ βουλῇ analyzed as noun, feminine, dative, singular, from lexent.n1
- ✓ καί analyzed as indeclinable, conjunction, from lexent.n5
- ✓ τῷ analyzed as adjective, masculine, dative, singular, no degree, from lexent.n4
- ✓ δήμῳ analyzed as noun, masculine, dative, singular, from lexent.n2

Figure 8: literary Greek

# Analysis

- ✓ EDOXSEN analyzed as verb, third, singular, aorist, indicative, active, from lexent.n3
- ✓ TEI analyzed as adjective, feminine, dative, singular, no degree, from lexent.n4
- ✓ BOLEI analyzed as noun, feminine, dative, singular, from lexent.n1
- ✓ KAI analyzed as indeclinable, conjunction, from lexent.n5
- ✓ TOI analyzed as adjective, masculine, dative, singular, no degree, from lexent.n4
- ✓ DEMOI analyzed as noun, masculine, dative, singular, from lexent.n2

Figure 9: Attic Greek

# Generated

- ✓ lexent.n6 in masculine, nominative, singular, generated as νόμος
- ✓ lexent.n3 in third, singular, aorist, indicative, active, generated as ἔδοξε
- ✓ lexent.n4 in feminine, dative, singular, no degree, generated as τῇ
- ✓ lexent.n1 in feminine, dative, singular, generated as βουλῇ
- ✓ lexent.n5 in indeclinable, conjunction, generated as καί
- ✓ lexent.n4 in masculine, dative, singular, no degree, generated as τῷ
- ✓ lexent.n2 in masculine, dative, singular, generated as δήμῳ

Figure 10: literary Greek

## Pipeline

Output of Attic analysis fed as input to literary generator:

EDOXSEN -> ἔδοξε  
TEI -> τῇ  
BOLEI -> βουλῇ  
KAI -> καί  
TOI -> τῷ  
DEMOI -> δήμῳ

## Current state

- largely completed in 2016 using Stuttgart FST toolkit + Java/Groovy custom classes
- summer 2017: porting custom classes to Scala substantially complete
- initial test corpora from HMT project:
  - complete *Iliad* manuscripts
  - more than 10,000 scholia

# Possibilities

- morphologically sensitive structured searching
- lexically unified corpus for latent pattern analysis
- integration of corpora in distinct writing systems or dialects
- pedagogy with epigraphic material in distinct writing systems or dialects?

# Thank you!

For more information:

- “Morphological Analysis of Historical Languages,” *BICS* 59-2 (2016) 89-102.
- <https://github.com/neelsmith/kanones>