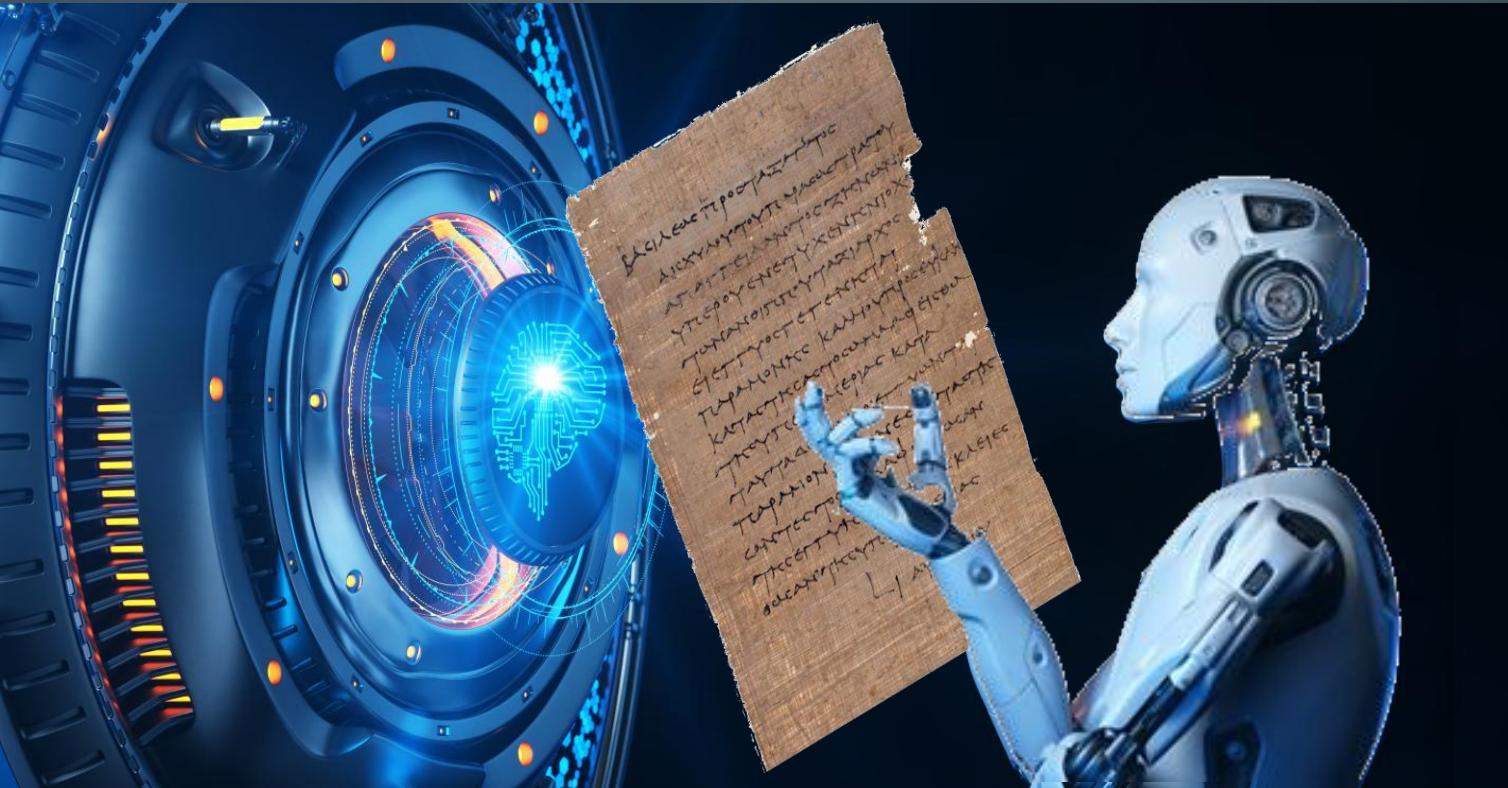


THE ARTIFICIAL PAPYROLOGIST AT WORK

Digital Papyrology and the AI



NICOLA REGGIANI

University of Parma – University of Udine



Artificial intelligence (AI) has been increasingly used in the field of papyrology, which is the study of ancient texts written on papyrus and other materials. The application of AI to papyrology can be broadly divided into two main areas: digital papyrology and computational papyrology.

Upvote
Report

Digital papyrology refers to the use of digital technology, such as imaging and digitization, to study ancient papyri. AI can be used in this context to enhance the process of imaging and digitization, for example, by automatically detecting and correcting distortions in images, or by using machine learning algorithms to classify different types of papyri.

Computational papyrology refers to the use of computational methods, such as natural language processing (NLP) and text mining, to analyze and interpret the content of ancient papyri. AI can be used in this context to support the process of transcription, translation, and annotation of the texts. For example, AI algorithms can be used to identify and transcribe different scripts, or to automatically classify texts by genre or date.

Another area that AI is used in papyrology is the classification of handwriting, which can be a time-consuming task for papyrologists. AI algorithms can be trained to recognize and classify different handwriting styles, which can help to identify the scribe and the date of a text.

AI can also be used to enhance the searchability and accessibility of papyrological data. For example, AI-based search engines can be used to search for specific words or phrases in large collections of papyri, and machine learning algorithms can be used to automatically classify and tag papyri based on their content.

In conclusion, AI has the potential to greatly enhance the field of papyrology by providing new and efficient methods for the study and interpretation of ancient papyri. However, it is important to note that AI should be used in conjunction with traditional methods of papyrological analysis, and should not be seen as a replacement for human expertise and interpretation.



Artificial Intelligence decoding an ancient Greek papyrus, depicted by Dall-E AI

«The Papyrologist at Work»

E.G. TURNER, *The Papyrologist at Work*,
GRBS Monogr. 6, Durham NC 1973.

Our first task is to set out precisely what the papyrus says, and to distinguish between what is certain or given by the text and what is a matter of inference. This is the prime responsibility of the papyrologist. It is often not fulfilled with the scrupulousness and unambiguity desired. We shall see how difficult a task it is (not to read the original but to make explicit our hypotheses during reading of a torn patch).





«The Papyrologist at Work»



In this first lecture I have tried to lead you step by step through the process of discovery and exploitation of a new piece of information, won unexpectedly from written relics of the past. The pleasure, indeed thrill, of discovery is the reward for a great deal of drudgery: meticulous attention to exact setting out of what the papyrus contains, step-by-step testing of the hypotheses on which even simple restoration is undertaken. This I take to be the meaning of editing, and this is the proper task of a papyrologist. He will not do it well unless he attempts a further step—to reconcile what is new with what was already known. But since he cannot be a universal polymath, he will defer here to the opinions of others. Unless his text, however, is completely reliable, counsel will be darkened, not lightened, by his discoveries. I hope in the next lecture to discuss three literary texts (one recently published, one quite new, and one known for some time) which will further illustrate the importance of careful editing.

The papyrologist as a «skilled reader», a «learned copyist», an «artificer of fact»

H.C. YOUTIE, *The Papyrologist: Artificer of Fact*, GRBS 4 (1963), 19-32.

H.C. YOUTIE, *The Textual Criticism of Documentary Papyri. Prolegomena. II Ed.*, London 1974.

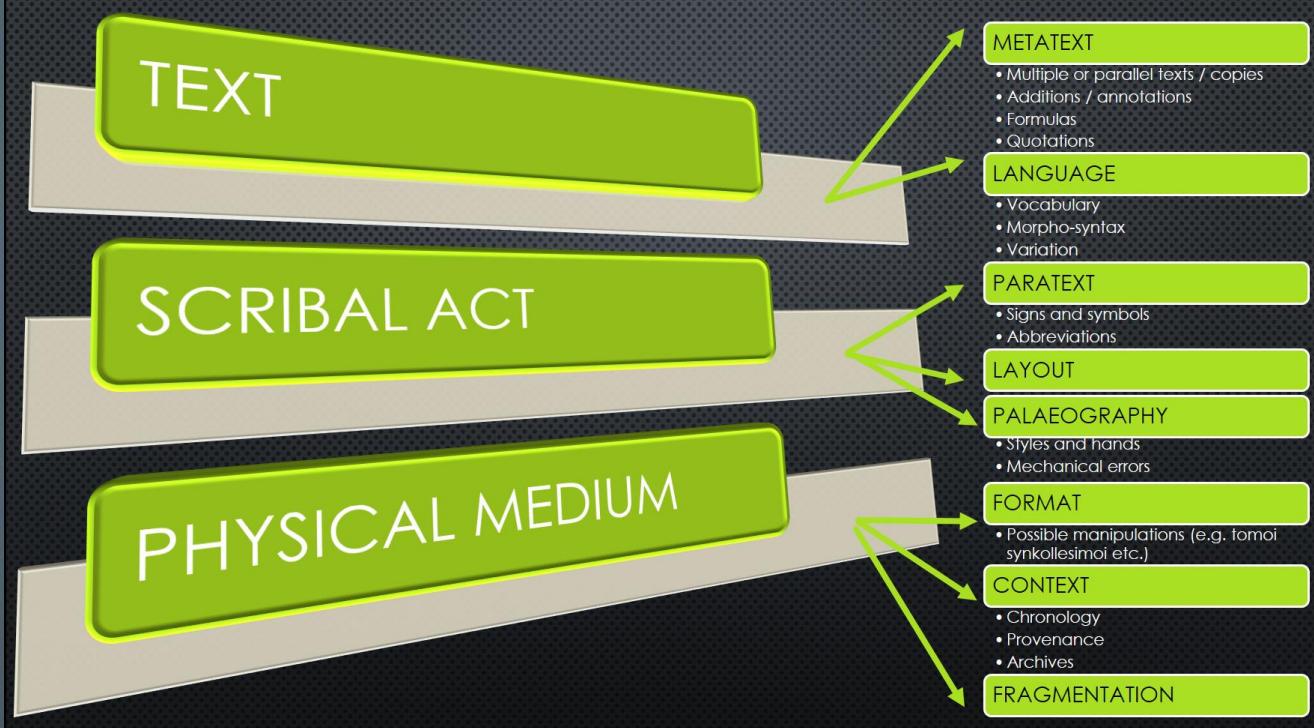
From the Digital Papyrologist...



Papyrology as a «discipline in flux» (Hanson 2002) and needs to undergo a «liquid philology» that envisages editorial changes and scholarly progress through time.

Since we cope with ever-changing facts, the aim of digital criticism is to keep track of all of them in an open and liquid edition which is a digital representation of the papyrus text.

A papyrus is a complex network of cognitive interactions. Digitally, it may (and should) become a meta-papyrus (Gagos 1998) that configures itself as a further step in the textual transmission rather than a fixed *Urtext*.



P.Flor. II 259: letter of Timaios to Heroninos (Theadelphia, AD 259-268)

Τίμαιος Ἡρωνίνοι τῷ[ι]
φιλ(τάτῳ) χαίρειν. καν νῦν
καιρὸν ἔχεις ἀναπέμψαι ἢ τὰ
σιτάρια ἢ τὴν τιμὴν καὶ
μαθέτω δὲ Κιοτ' ὅτι ἐὰν μὴ
δη τὸν ἄλλον σάκκον ἢ
ἀνέλθῃ καὶ τὸ κατ' αὐτὸν
ἔνθη στρατιώτης κατέρχεται
ἐπ' αὐτὸν. ἀλλὰ πάντως
ἀναπέμψον αὐτὰ. ἐρρόσθαι
σε εἴχομαι.

ἄλλοι μέν ῥα θεοί τε καὶ
ἀνέρες ἵπποκορυσταὶ
εὗδον παγγύχιοι. Δία δ' οὐκ
ἔχε νήδυμος ὕπνος.
εὗδον παννυχί



MAIN BODY

- Severe style
- Appropriate layout
- Mechanical errors: 7. μὴ δη
I. μὴ δῶ
- Linguistic variation: 9.
κατέρχεται I. κατέρχεται
- Linguistic use: 3. καν I. καὶ ἂν;
iota adscript
- **Graphical sign:** Κιοτ'

THE PAPYRUS AS HYPERTEXT:

An interactive network of interconnected cognitive layers



MATERIALITY

- Physical framework: pre-cut sheet
- Relationship text-support: recto along the fibres, blanks, verso

INITIAL GREETINGS

- Epistolary formula
- Epistolary layout
- **Abbreviation**

FINAL GREETINGS

- Epistolary formula
- Special layout
- Cursive, personal hand

MARGINAL ADDITION

- Reuse of left-hand margin
- Stylish hand
- Quotation: Hom. Il. II 1-2
- Further personal annotation

The availability of huge amounts of information in fully searchable textual form with accompanying images through these new media is altering drastically the definition of what constitutes a "text", the way we experience reading it and, ultimately, the plurality of messages a text can offer to one or more readers. The new methods of presenting text with marked up images and the simultaneous availability of a variety of other research tools within the

same electronic environment give us new ways of visualizing and approaching a given text. An edited text is no more a static, isolated object, but a growing and changeable amalgam: the image allows the user to look critically at the "established" text and to challenge continuously the authoritative readings and interpretation of its first or subsequent editors.

Furthermore, the simultaneous access to and study of thousands of texts and their images that could be as far apart as a millennium, in a single search and through the same medium, has the potential to challenge our established notions of the "messages" a text carries within itself, its textuality and intertextuality and, ultimately, the periodization of texts in strict chronology of political events. A text that was written, for instance, in the era of Caracalla contains information and "signifiers" that operate beyond and above that particular period and era. The use of names, formulae, language at large,

references to past events, and even the appearance of this text (e.g. the type of handwriting, often used by papyrologists to date other texts, or the layout) is in a constant dialogical relationship with other texts and their historical contexts, because it draws upon and is part of the multiplicity of meanings that circulate within culture and history. As Roland Barth explains: "Any text is an intertext; other texts are present in it, at varying levels, in more or less recognizable forms: the texts of the previous and surrounding cultures. Any text is a new tissue of past citations. Bits of codes, formulae, rhythmic models, fragments of social languages, etc. pass into the text and are redistributed within it, for there is always language before and around the text"⁸. In one or another way, papyrologists have always recognized the "intertextuality" of the Greek papyri from Egypt, because of the multicultural and multi-ethnic environment in which these texts were born. The development of the new electronic media in our field and the capability to establish these cross-links – or these intertextual signifiers, so to speak – on the linguistic, cultural and historical level through the interaction of multiple texts, images and a variety of related tools places the notions of textuality, intertextuality and

metatextuality on a new (electronic) platform which, in turn, becomes part of these notions as the "carrier", "interpreter" and "distributor" of these texts.

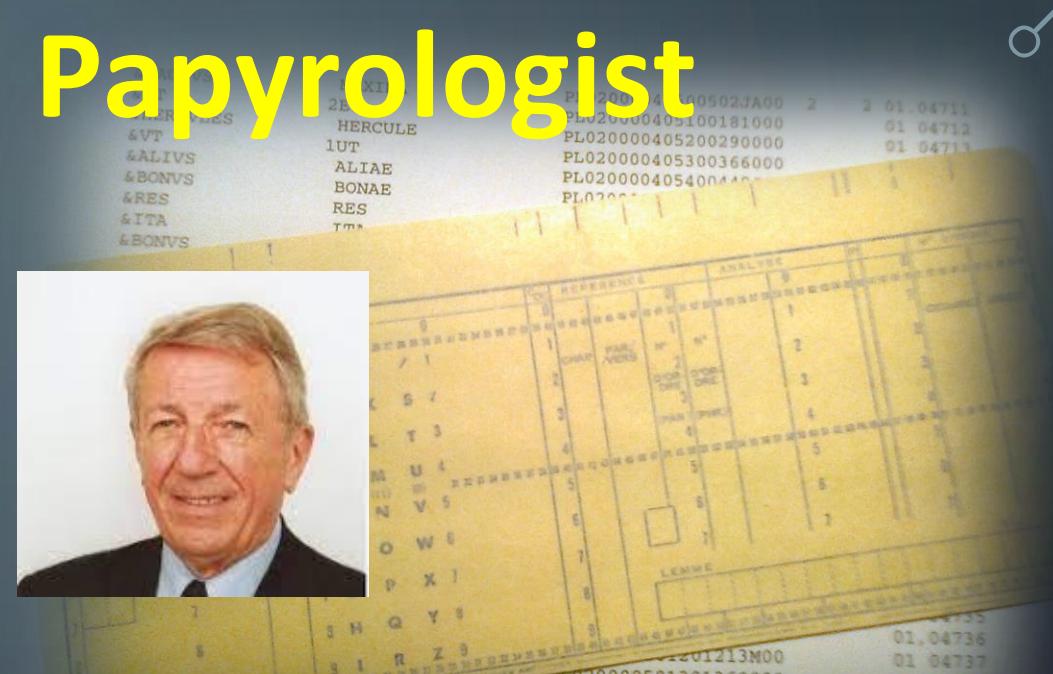
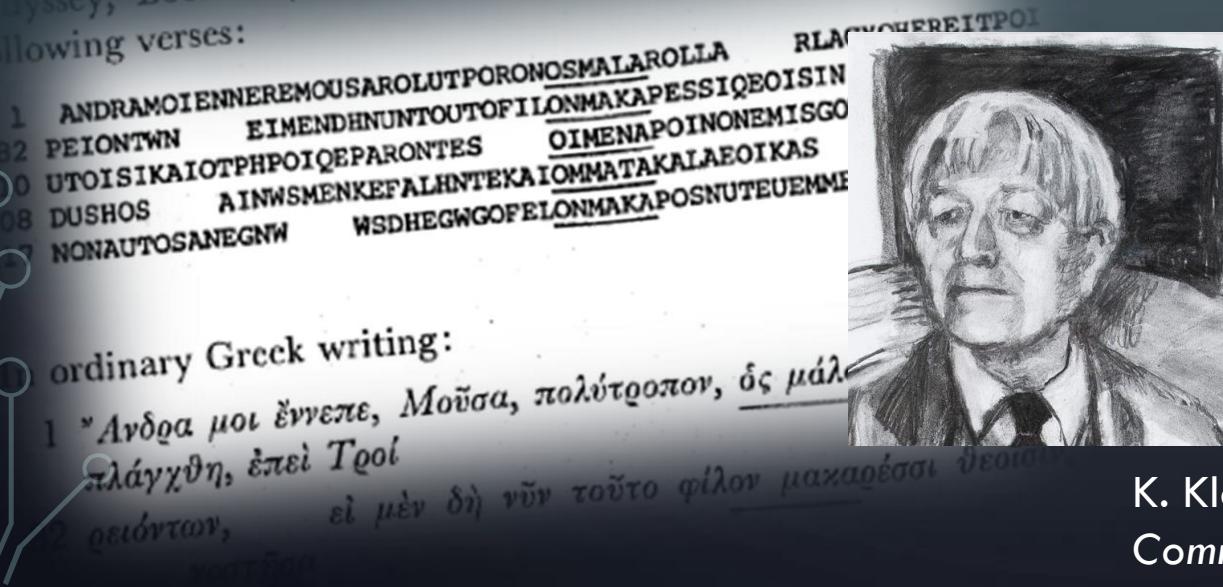


T. Gagos, *The University of Michigan Papyrus Collection: Current Trends and Future Perspectives*, Pap.Congr. XXII (2001), 514-6.

...to the Artificial Papyrologist

Il resterait à dire comment furent réalisées les diverses parties du travail que nous vous avons remis. En fait, le processus est le même dans chaque cas: le fichier étant dans un ordre déterminé, il est traité par l'ordinateur au moyen d'un programme adapté aux exigences des papyrologues et les résultats des opérations sont imprimés automatiquement. Le rôle du papyrologue se réduit, à ce stade, à poser des questions. Le laboratoire est là pour trouver les moyens d'y répondre. Vient alors le travail de réflexion sur les documents fournis; mais ceci n'est plus de notre compétence: les machines peuvent aider les spécialistes dans leurs recherches en leur fournissant rapidement des données sûres; elles sont incapables de résoudre les vrais problèmes. Il faut encore d'excellents papyrologues.

A. Bodson, *Exploitation automatique de la documentation papyrologique: application à un corpus*,
Pap.Congr. XII (1970), 44.



We want to stress that we do not in the least expect that some time the scholar shall be replaced by the computer. On the contrary, as far as we can see, what now happens is that the scholar gets access to new aids and has been freed from many unnecessary burdens. He has, one could say, got a sort of magic lexicon in addition to the traditional reference books. In this magic lexicon there are endless possibilities of sorting and arranging text material in a minimum of time. But no other than the scholar is able to *use* that lexicon. Wilhelm Crönert once emphasized that there are three cardinal virtues for the papyrologist: *Sehkraft*, *Sprachgefühl*, *Sachkunde*.¹⁹ These virtues are today as relevant as ever they were, and can never be replaced by any computer.

K. Kleve – I. Fonnes, *Lacunology: On the Use of Computer Methods in Papyrology*, SO 56 (1981), 165.

Automated «Sehkraft» (Deciphering & identifying hands)



Fig. XV. Drawing with magnetic cursor on a digitizing tablet.

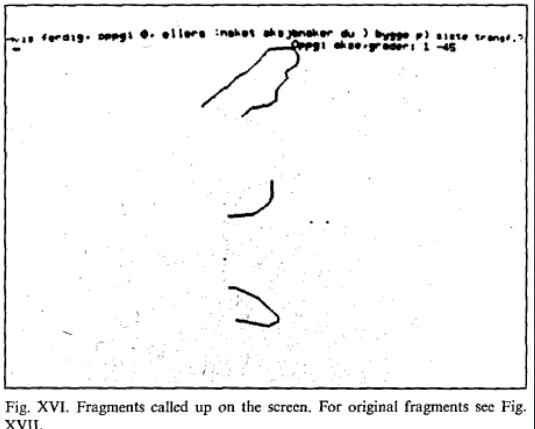


Fig. XVI. Fragments called up on the screen. For original fragments see Fig. XVII.



Fig. XVII. Microscope slide, originally in colours, of unregistered part of PHerc 26, cornice 1 (Philodemus, On the Gods I).¹² The three fragments in Fig. XVI are to the right of the hole in the middle (see arrows). Microscope: cf. Fig. IX. Camera: Leica CL. Film: Ektachrome 60. Time: 8 sec. Microscope iris diaphragm 6. Indirect sunlight.

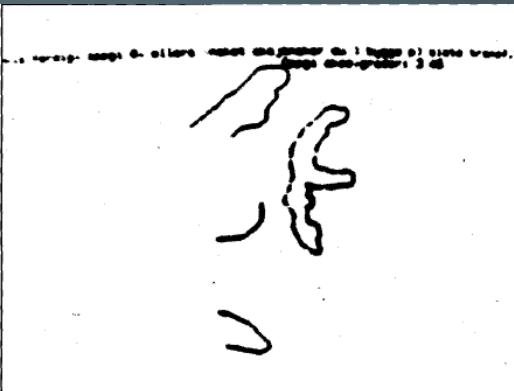


Fig. XIX. Epsilon rotated.

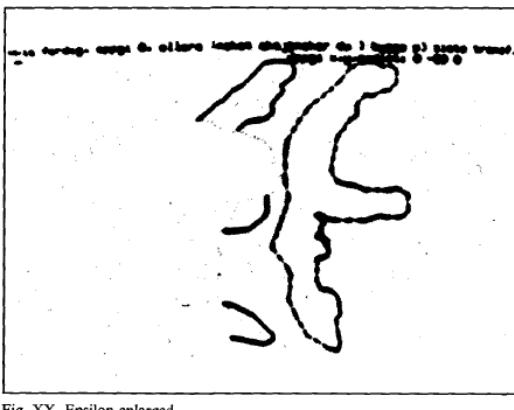


Fig. XX. Epsilon enlarged.

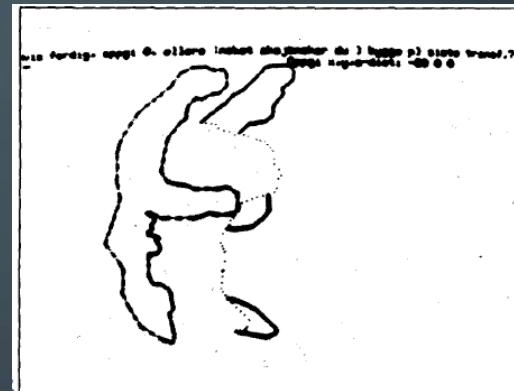


Fig. XXI. Epsilon placed in new position.

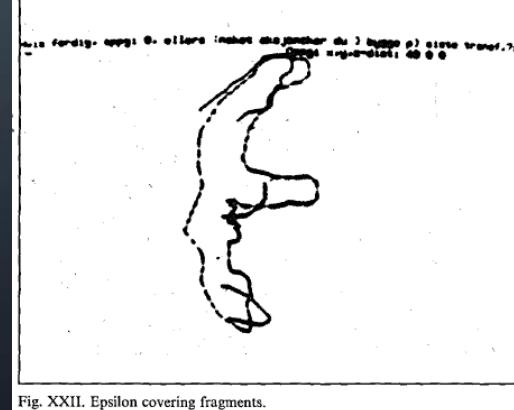
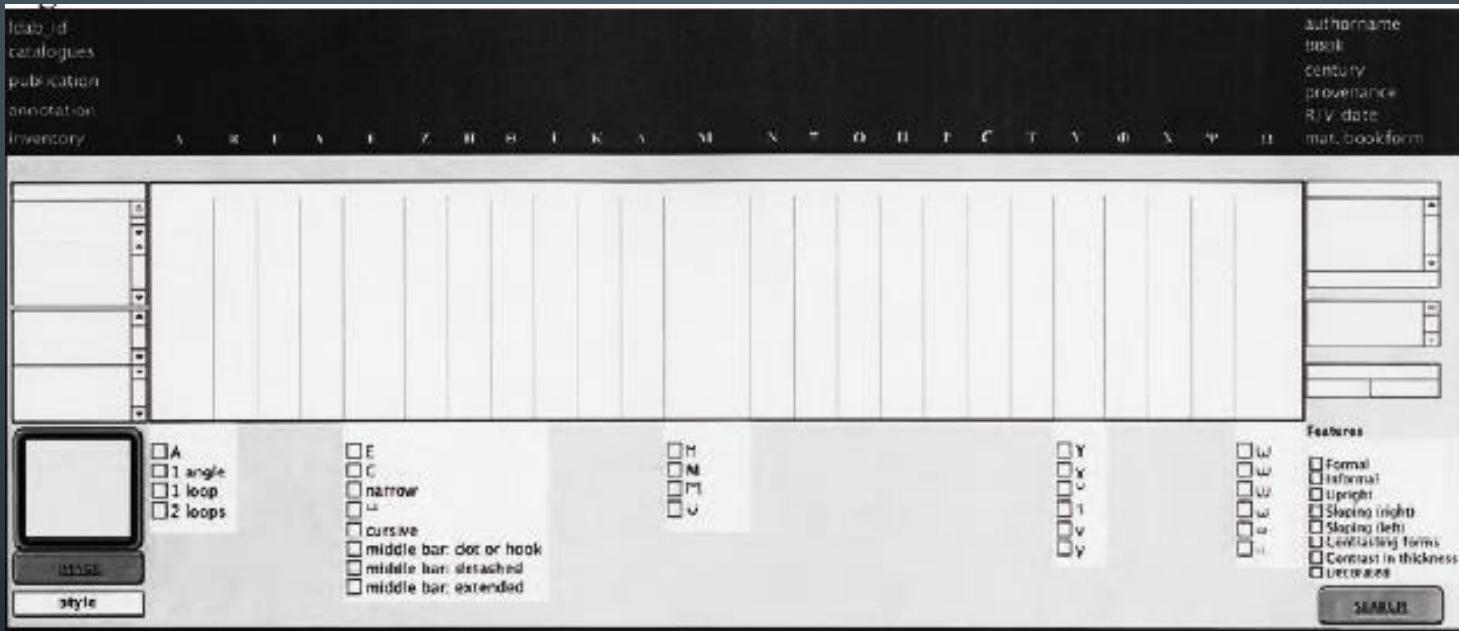


Fig. XXII. Epsilon covering fragments.

Automated «Sehkraft» (Deciphering & identifying hands)



G. Menci, *Utilità di un database di alfabeti per lo studio della scrittura greca dei papiri*,
Pap.Congr. XXVI (2012), 525-8.

Introduction

eSAD Image Processing Tool

26.01.2010 - KCL E-Science and Ancient Documents Image processing 21

MA-DCT Core. w16 - part 2.

EPSRC International Research Institute JISC Arts & Humanities Research Council

Leiden Convention mark-up - EpiDoc XML

- Is a set of symbols used to show where an interpretation is not clear, where text is added or deleted.
 - Only the last character 'm' is perfectly legible.
 - [u] is a gap that has been filled in with what the expert supplied.
 - t e are two characters found but unclear in the text.

26.01.2010 - KCL E-Science and Ancient Documents Knowledge base and encoding 24

MA-DCT Core. w16 - part 2.

EPSRC International Research Institute JISC Arts & Humanities Research Council

Evidence based decision process

CLICK!

CURRENT INTERPRETATIONS

Character: h
Change character:

- + Word: hordearia
- + AKB: h, 'Because I say so'
- + Word search: hordearia, hordeiator(ex)
- Character recognition: n, r

Evidence for the character H

26.01.2010 - KCL E-Science and Ancient Documents Rationale recording 27

MA-DCT Core. w16 - part 2.

EPSRC International Research Institute JISC Arts & Humanities Research Council

"The case of the disappearing ox"

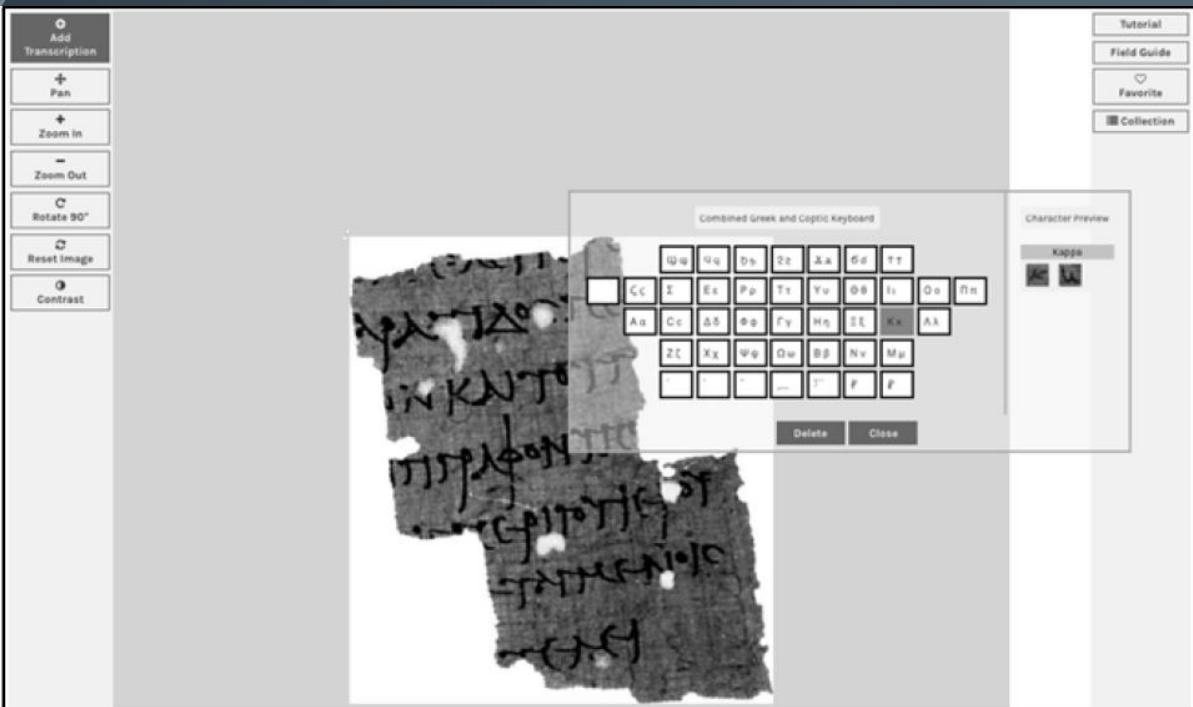
26.01.2010 - KCL E-Science and Ancient Documents 3. Argumentation, justification 30

MA-DCT Core. w16 - part 2.

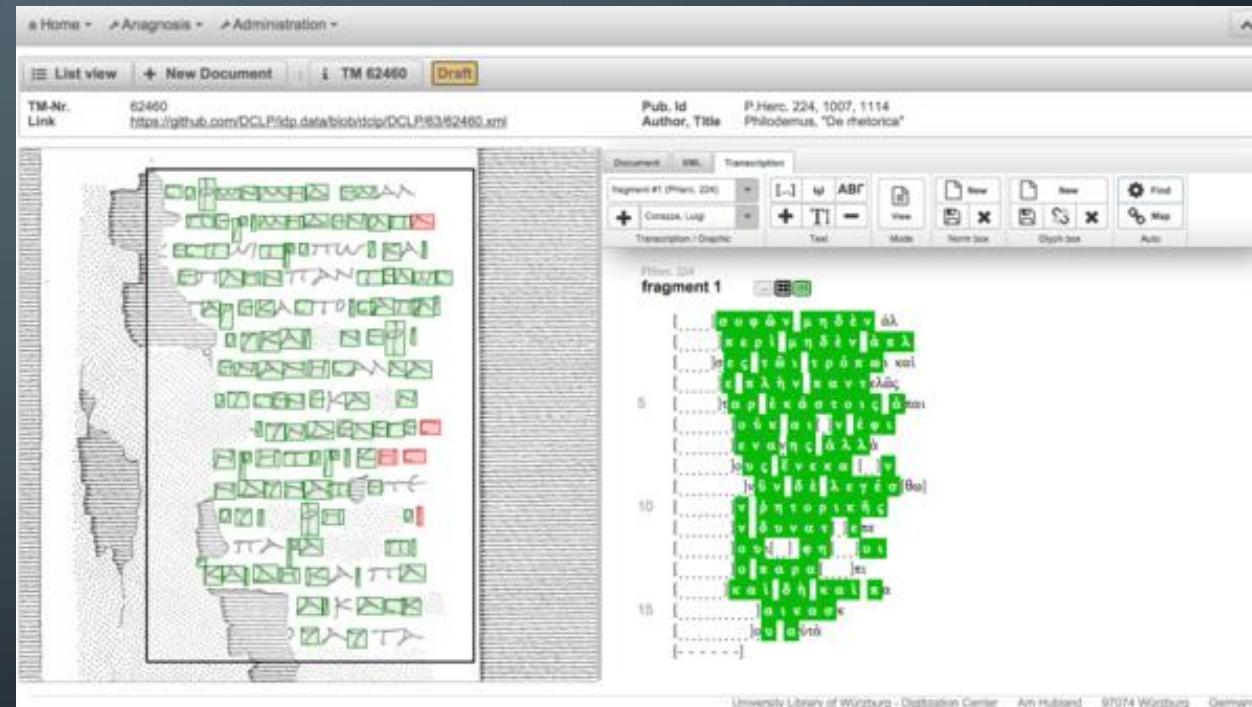
EPSRC International Research Institute JISC Arts & Humanities Research Council

S. Tarte, *E-Science and Ancient Documents. An example of what e-Science can do for papyrologists, 2010* (on Academia.edu)

Automated «Sehkraft» (Deciphering & identifying hands)



Ancient Lives



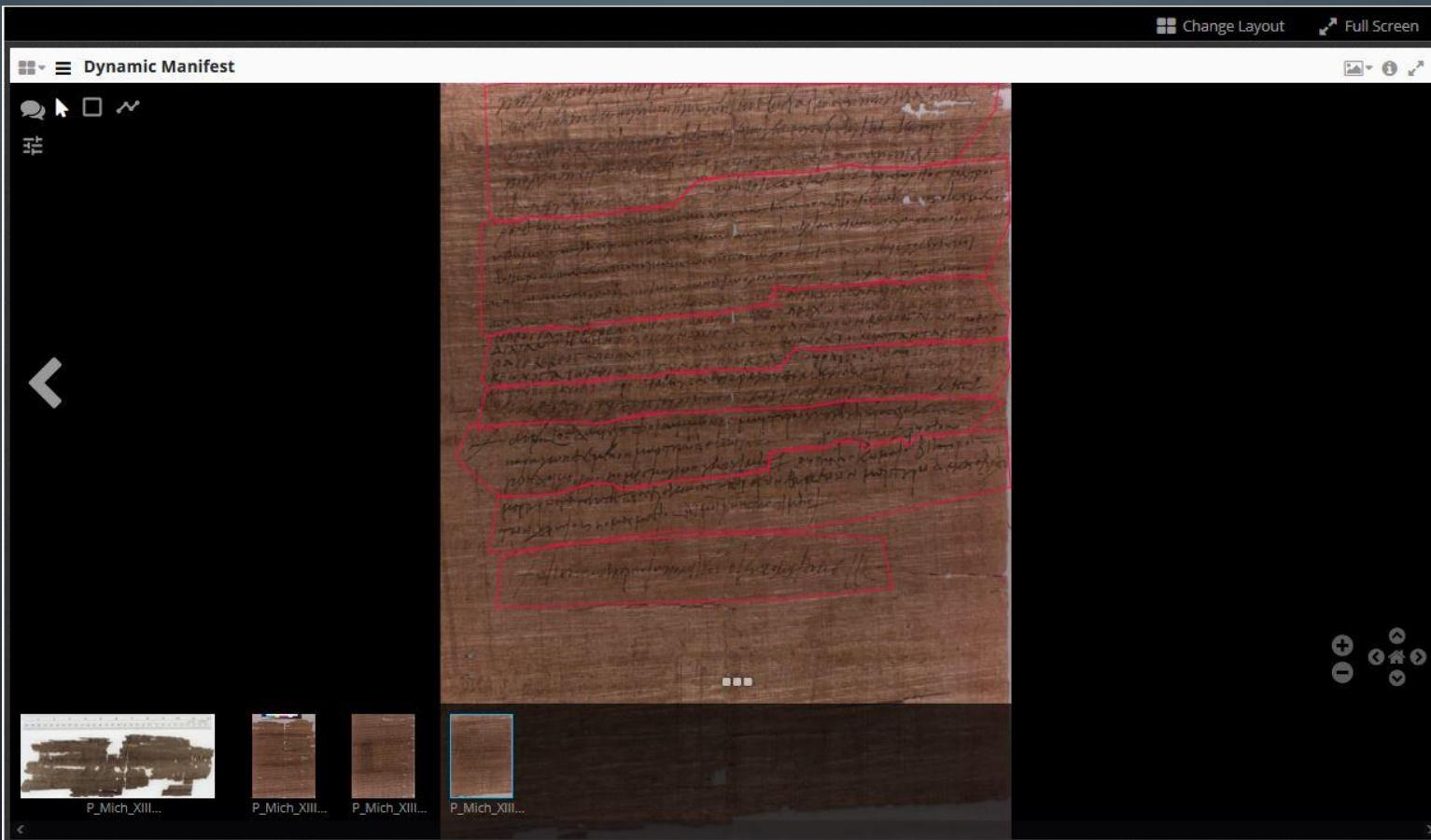
Anagnosis

Automated «Sehkraft» (Deciphering & identifying hands)



B. Kiessling – D. Stökl Ben Ezra – R. Ast – H. Essler, *Aligning extant transcriptions of documentary and literary papyri with their glyphs* (on Academia.edu)

Automated «Sehkraft» (Deciphering & identifying hands)



Automated «Sehkraft» (Deciphering & identifying hands)

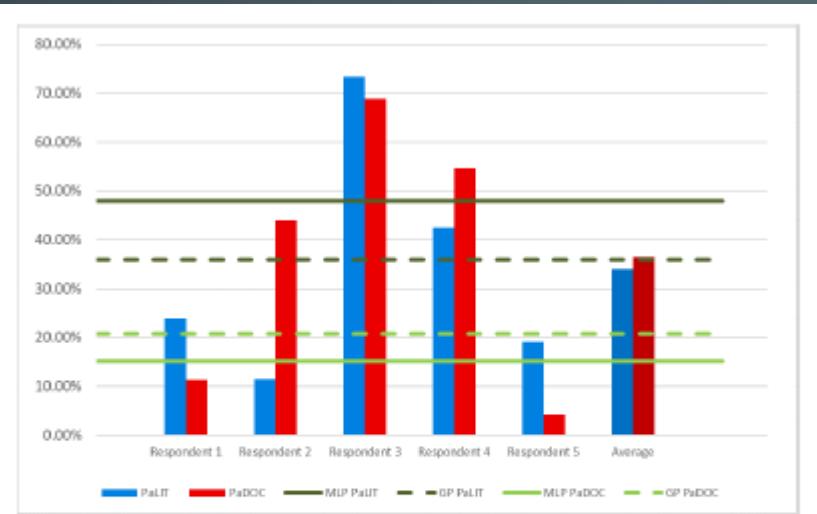


Fig. 7 Respondents' F1 (higher is better) for literary (PaLIT; in blue) and documentary (PaDOC; in red) papyri. The respective systems' scores are shown in green horizontal lines; dark for literary, light for documentary; solid for MLP, dashed for GP.

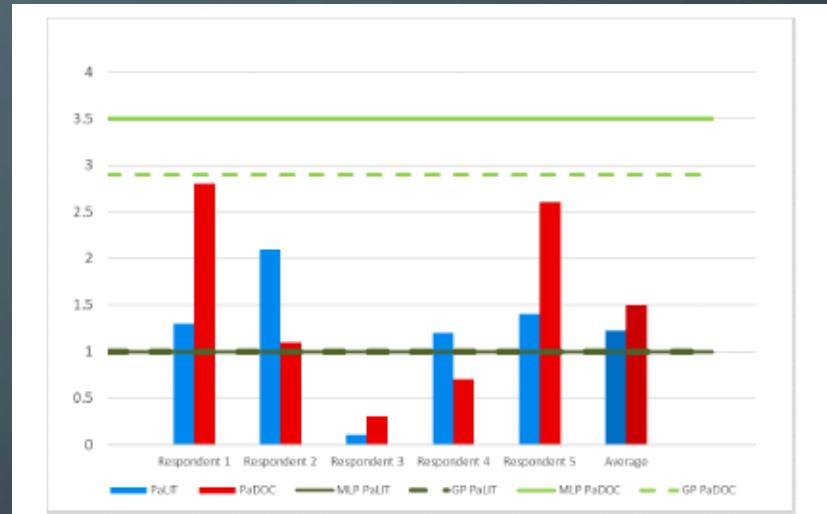
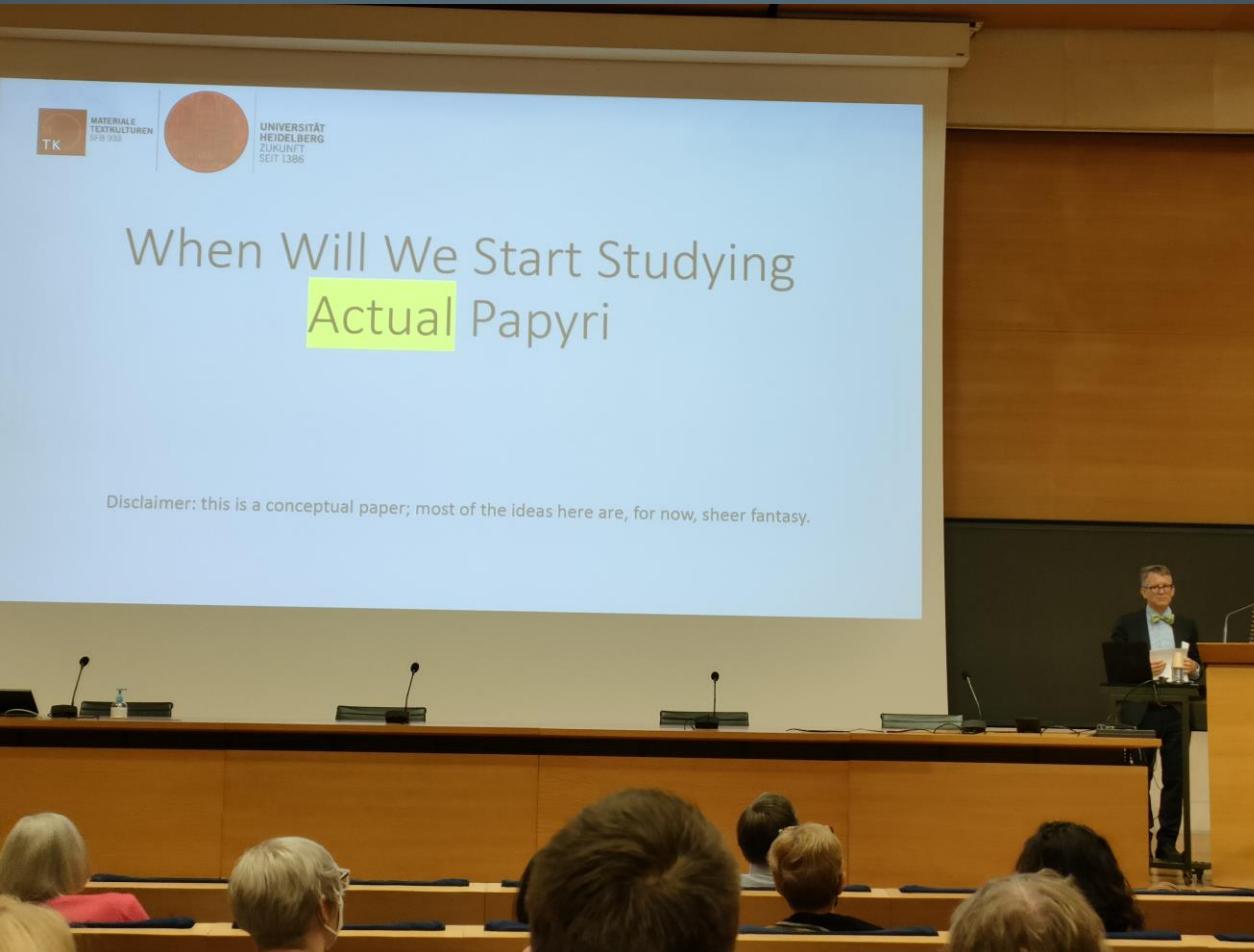


Fig. 8 Respondents' MAE (lower is better) for literary (PaLIT; in blue) and documentary (PaDOC) papyri. The respective systems' scores are shown in green horizontal lines; dark for literary, light for documentary; solid for MLP, dashed for GP.

Automated «Sehkraft» (Deciphering & identifying hands)



Automated «Sehkraft» (Deciphering & identifying hands)



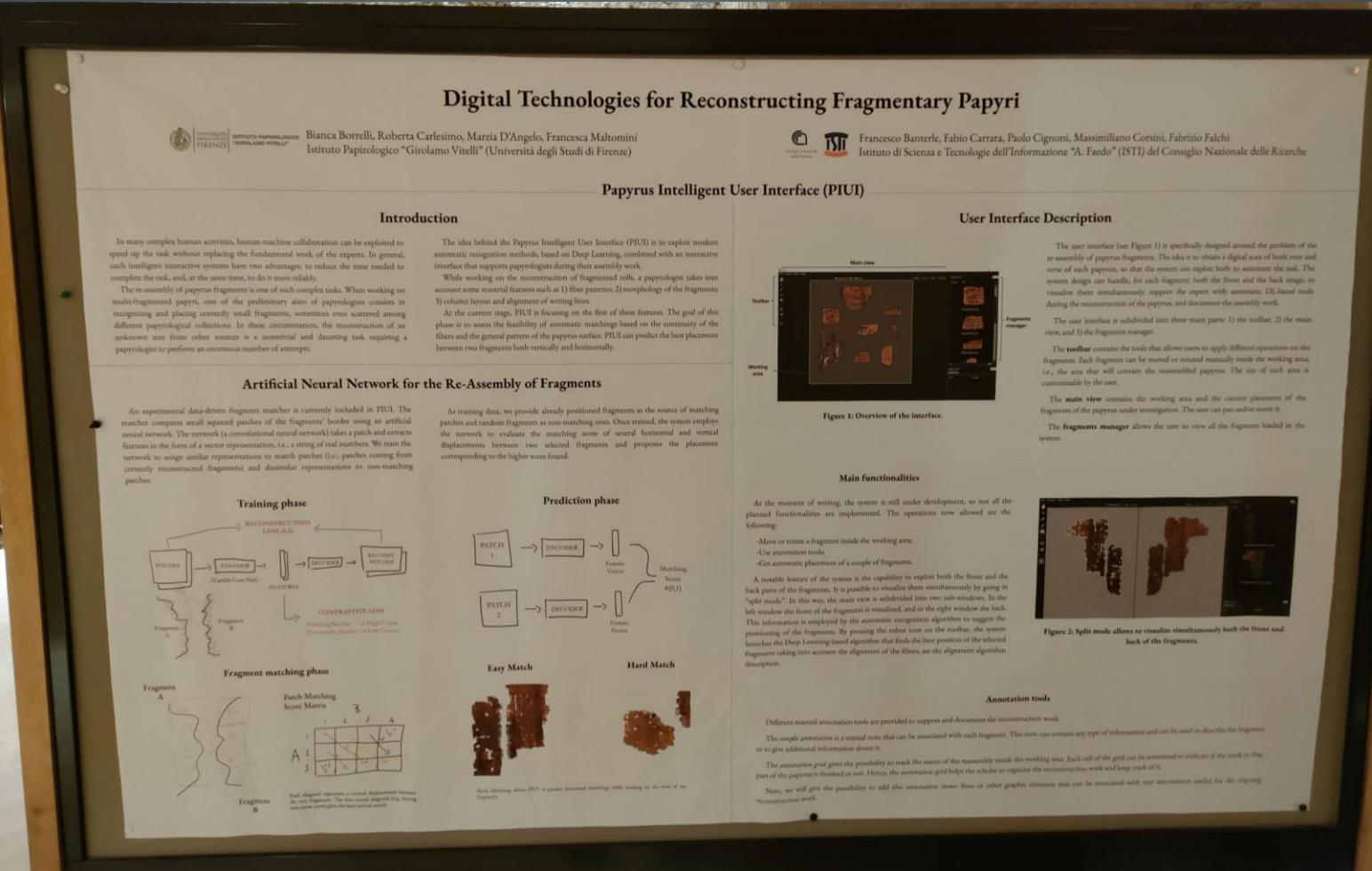
Figure 6: Images of synthesized Psi and Xi.



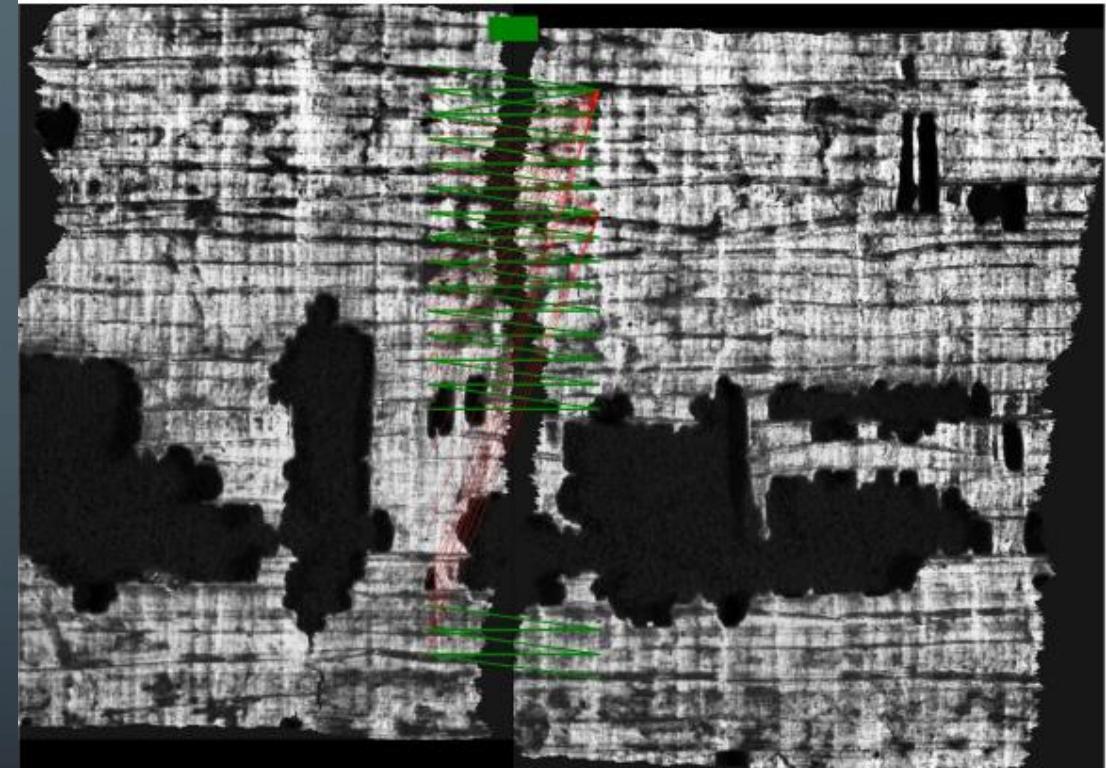
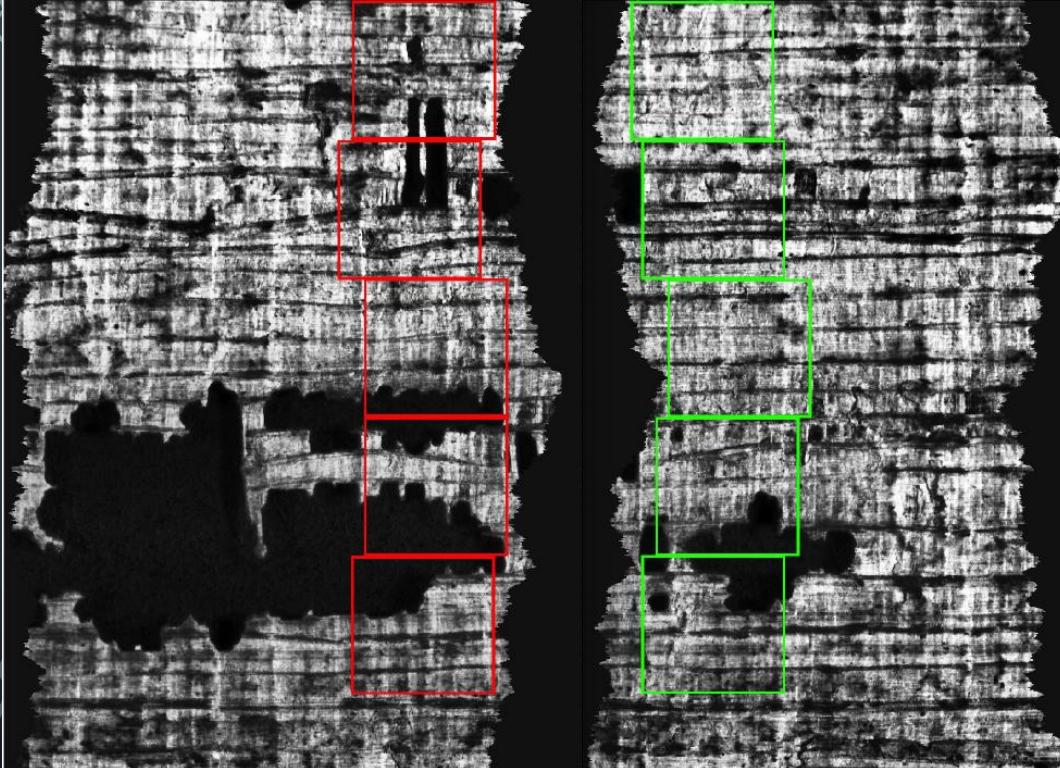
Figure 7: Images of Synthetic Alpha, Delta, & Pi

M.I. Swindall – T. Player – B. Keener – A.C. Williams – J.H. Brusuelas – F. Nicolardi – M. D’Angelo – C. Vergara – M. McOsker – J.F. Wallin, *Dataset Augmentation in Papyrology with Generative Models: A Study of Synthetic Ancient Greek Character Images*, in *Proceedings of the Thirty-First International Joint Conference on Artificial Intelligence (IJCAI-22)*, 4973-9.

Automated «Sehkraft» (Restoring fragments)

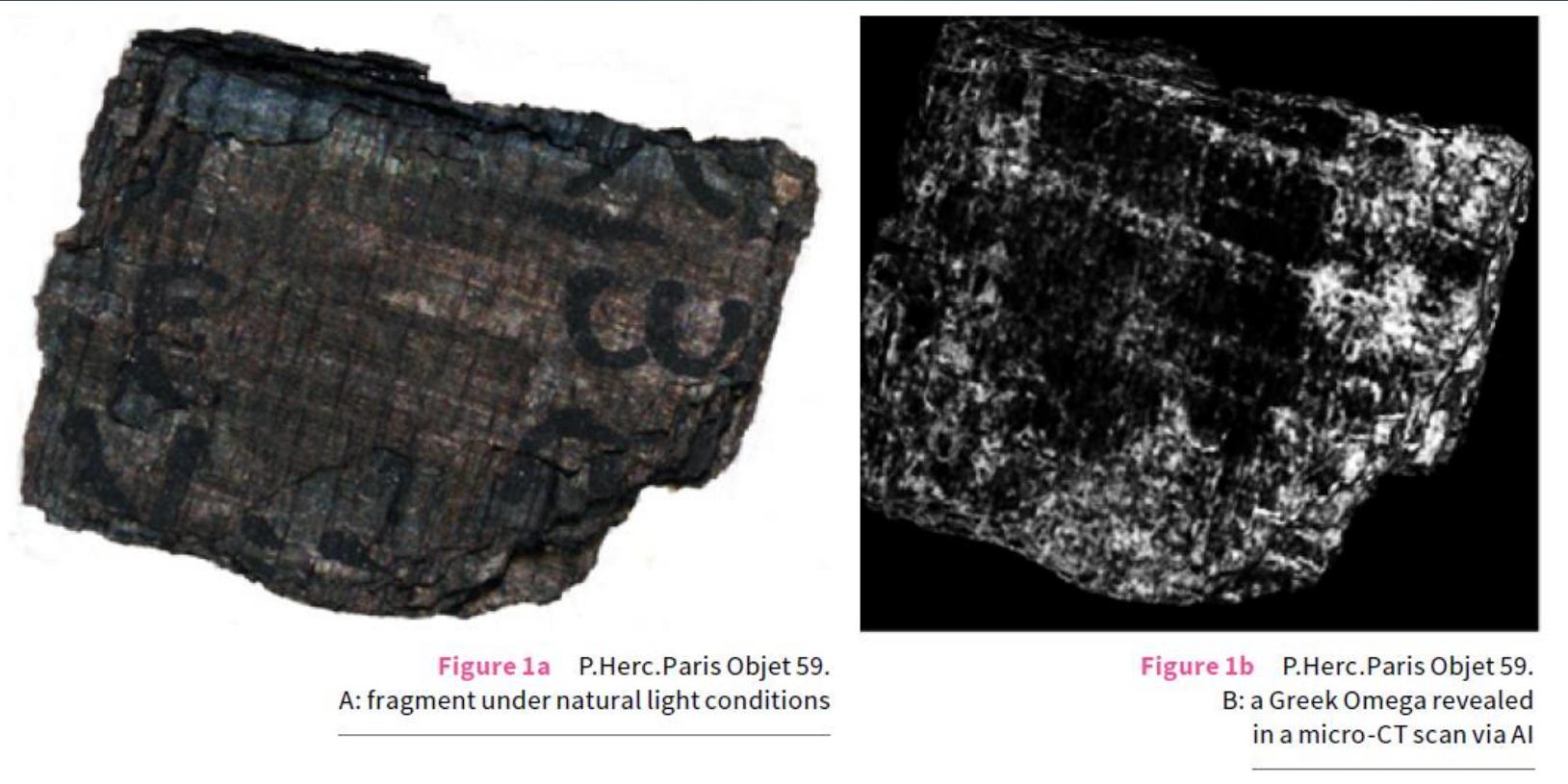


Automated «Sehkraft» (Restoring fragments)



R. Abitbol – I. Shimshoni – J. Ben-Dov, *Machine Learning Based Assembly of Fragments of Ancient Papyrus*, Journal on Computing and Cultural Heritage 14 (2021), # 33.

Automated «Sehkraft» (Restoring fragments)



K. Fleischer, *Die Papyri Herkulaneums im Digitalen Zeitalter: Neue Texte durch neue Techniken - eine Kurzeinführung*, De Gruyter, Berlin – Boston 2021.

J.H. Brusuelas, *Scholarly Editing and AI: Machine Predicted Text and Herculaneum Papyri*, Magazén 2 (2021), 45-70.

Automated «Sprachgefühl» (Linguistic analysis)

Treebank

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```

T Words About Session for Università d
Enter Greek word Go Log in with a personal a

Words

Type in a word or translation: ? Enter Greek word Go

To search for morphological features, click [here](#).

Click any of the letters below to limit your search to words starting with that letter:

a - β - γ - δ - ε - ζ - η - θ - λ - κ - ρ - ν - ο - π - ρ - σ - τ - υ - φ - χ - ψ - ω

Any lemma type ▾

Page 1 of 798 > »

TM Word Id	Word ??	Type	Translation	Frequency !?
	ό ?	article	the	352464
	καλ ?	coordinator	and	162946
	δραχμή ?	noun	drachme (weight or money)	68002
	ἔτος ?	noun	year	57842
	αὐτός	demonstrative	self; him, her (declined cases)	52968
	έγώ	personal	I, me	42118
	γίγνομαι	verb	come into being; become; makes in totla (3rd pers.)	41466
	α	numeral	number: 1	40593
	άρταβη	noun	artaba	36898
	διά	preposition	through, because of	35256
	Ιανουάριος	preposition	January	32004

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Automated «Sprachgefühl» (Linguistic analysis)

The screenshot shows a GitHub repository page for 'gcelano / MALP'. The repository is public and has 4 issues, 9 pull requests, and 1 action. It contains two files: 'texts' (added 5 years ago) and 'README.md' (updated 2 years ago). The README file is displayed below.

MALP

This repository contains the MALP (= M(orphologically) A(nnotated) (and) L(emmatized) P(apyri) corpus) corpus. This contains all the texts of papyri.info which could be automatically sentence splitted. You find documentation about its creation in the following article:

Celano, Giuseppe G. A. (2017). An automatic morphological annotation and lemmatization for the papyri of the Integrating Digital Papyrology Project (papyri.info). in Reggiani N. (ed.), Digital Papyrology II. New Tools for the Digital Edition of Ancient Papyri. De Gruyter. <https://www.degruyter.com/view/title/527972>

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Automated «Sprachgefühl» (Filling the gaps)

KATA M]EPOS LOGWN DIA[KORAS] ERI-MNHQSQH[S]OMEQA. TWN GAP ERISTH
ON EXOU[S]IN EK FU[SE-W]S] OFEILION RPQOULO-KEISQAI KAI E[RGIC]EIN
EWS [OLI]G]ON, [AI] DE D[I]' EAUTWAN TELESIOU[PQOUS] AI D[E K
AI] D' OU-D] D' OLWS EXOUSIN[XPEI-TAN SU[N]ASKHSE[WS, AL'-]LA F[U
OMEN[HS] TO RLE[IS]-TON D[I]' EAUTWN SUN-TELOUS[I]N. AI D' OU FU

In ordinary Greek writing (with references):

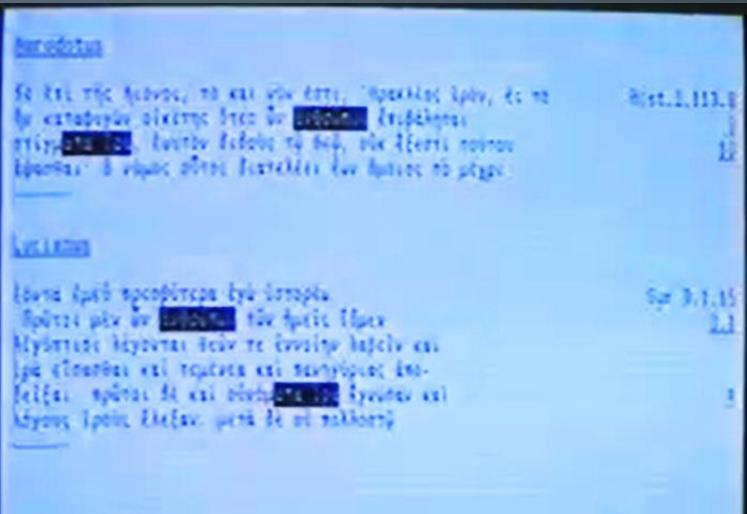
κατὰ μέρος λόγων δια[κοπάς] ἐπι-μυησθη[σ]όμεθα. Τῶν γὰρ ἐπιστη
(fr. 4,2f.,p.1)

ον ἔχου[σ]ιν ἐκ φύ[σε-]ω[ς] δῆθείλον προύπο-κεῖσθαι καὶ ἐ[πιγ]ένεται
(fr. 4,7,p.1)

*εως [δ]λιγ[γ]ον, [αι] δὲ δι[τ'] έαντων τελεσιου[ργούσθ]ιν, αἱ δὲ κ
(fr. 4,10,p.1)*

αὶ [δ' οὐδ-] δ' ὅλως ἔχουσιν [χρεῖ-] αὐ σν[ν] ασκήσε[ως], ἀλ-· λὰ φ[ν]
(fr. 2,31,p.2)

ομέρ[ης] τὸ πλε[ῖα]-τον δ[ι] [εἶναι] ἔαντων συν-τελοῦσ[ι]ν. Αἱ δὲ οὐ φέ
(fr. 2,8,p.2)



Pandora

Search card #8

Simple search:

πατέρα

Whole words or phrases
 Fragments
 Accents important
 Match unknowns

Search in:

DDP0085 • Πλάκων
DDP0086 • Πλάκων
DDP0087 • Πλειδαμίας
DDP0088 • Πλειδινστ
DDP0089 • Πλειδιζ

Clear Search Complex search...

Select Works

Delete Work

Results: 70 citations:

πατέρας	PIFAO, Vol 2, document 30, 4 (?; IIspc)	Show Text
πατέρας	PIFAO, Vol 2, document 39, 9 (?; IV-Vspc)	Hide Text
πατέρα[PIFAO, Vol 2, document 45, r. 3 (?; I%3Ispc)	Other
πατέρας	PIFAO, Vol 2, document 48, Fra, 3 (?; III%3Ispc)	
πατέρας	PKoeln, Vol 5, document 222, 11 (Heranom, 145B-)	

Setup ? TOC Export Duplicate Index Search Do search

Papyri.info

Browse: DDbDP HGV APIS DCLP Authors TM Number or Search: Data Bibliography

Search New Search

within chars

and or not then near lex regex abbr start-not end-not

Convert from betacode as you type
 ignore capitalization
 ignore diacritics/accents

Text Metadata Translations

Series or	<input type="button" value="... All values ..."/> Vol.	<input type="text"/>
Collection	<input type="button" value="... All values ..."/> ID #	<input type="text"/>
Author	<input type="button" value="... All values ..."/>	<input type="text"/>
Work	<input type="button" value="... All values ..."/>	<input type="text"/>
Provenance	<input type="button" value="... All values ..."/>	<input type="text"/>

Records per page

Please select values from the left-hand column to return results

Selecting a value using the controls in the left-hand column will return a list of all documents that match it in the right-hand column. Once these results have been returned, the controls can be used to further refine the search with additional values. This process of adding new search constraints can be applied repeatedly until the results have been narrowed as far as desired.

More about string-search

The Papyrological Navigator (PN) allows both simple and complex string-searching across the entire corpus of documents in the database.

Simply entering characters into the search box at the top of the column and clicking 'Search' will return all documents containing that sequence of characters anywhere in their text.

Many more complex kinds of search are also possible, however.

Kinds of search

Automated «Sprachgefühl» (Filling the gaps)

eAQUA

Text

Διπλός Πατούτος Περανή ὁς (ἴταν) Ε μέση μελίχρω(ε) μακροπρόσω(πος) εύθυρη μετά κυρίου τοῦ έσυτής πρεσβυτέρου υἱοῦ Φενίνητος τοῦ Αρσιήλος Πέρασο τῆς ἐπιγονής ὁν (ἴταν) ν μέσου μελάνηρυτος (μποκάλιτου) ἀναφελάντου μακροπρόσωπου(πος) εύθυρην, δραστικών δεξιῶν βεβλαμένου ἀπό τῆς ὑπαρχόσας αὐτῆς και τοῖς ἀδελφοῖς γης στοφόρους ἀδιαρέτου ἐν τῇ τανιά Ποθίρεως λεγομένης Περώ Κοήτος τὸ ἐπιβάλλον αὐτῆς μέρος οὐ γείτονες νότου γη Σλήπιος, Βορρά γη Πανάτος, ἀπηλώτου) ποταμός, λιβός γη Αραμίτος ή οι ἄνω γείτονες πάντοτεν.

griechische Literatur

Inscriften / dokumentarische Papyri

Epidike

Sentence

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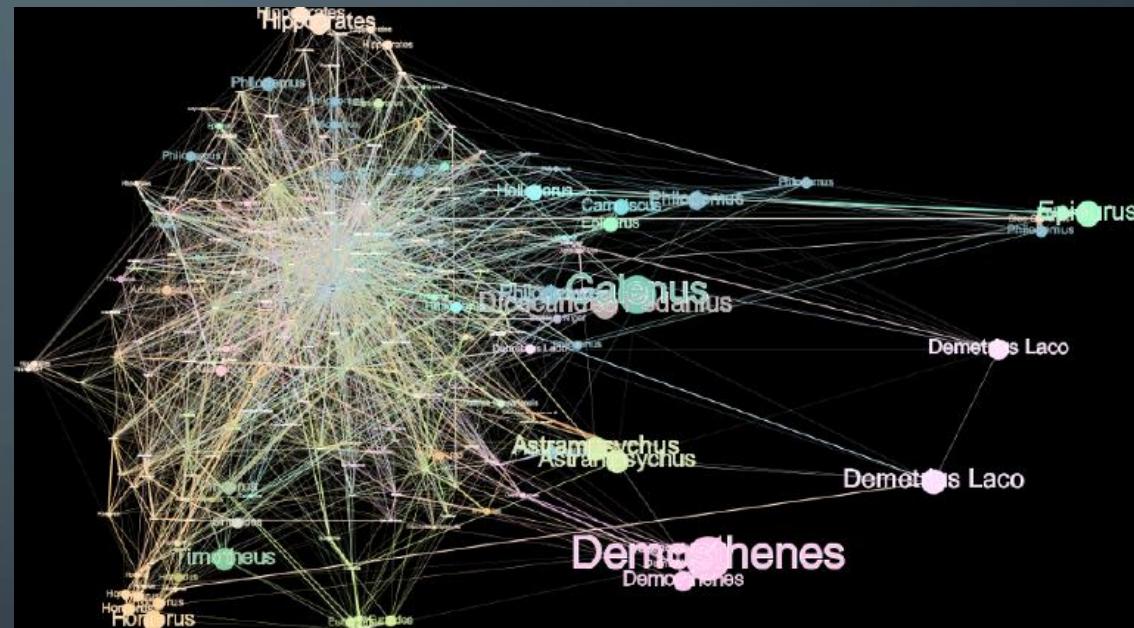
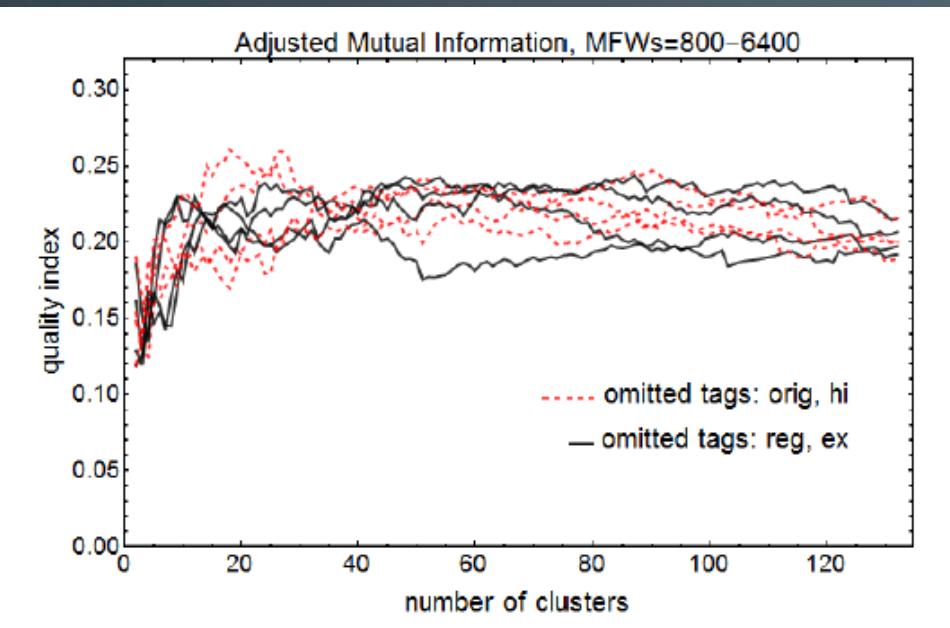
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Interpreted word : ὁ

Length : 7

Candidate	Score	<input type="checkbox"/> Word length	<input type="checkbox"/> Neighoured letter bigrams	<input type="checkbox"/> Word similarity (letters)	<input type="checkbox"/> Named Entity	<input type="checkbox"/> Word bigram	<input type="checkbox"/> Semantic context	<input type="checkbox"/> Classification	Show
ἀπέδοτο	6	1.0	3.0128546809192486E-5	1.0		0.5	0.25	0.140	
Χάρακος	4	1.0			1.0		0.05	0.000	
Ζοήρις	4				1.0	0.5	0.05	0.013	
Ικλαυδία	4	1.0			1.0		0.05	0.032	
όργυριο	4	1.0	4.132543685466394E-4	1.0				0.069	
Περανή	4	1.0			1.0		0.25	0.173	
διέρχομε	4	1.0	5.973693684009757E-6	1.0				0.083	
Αύρηκλια	4	1.0			1.0		0.05	0.121	
Ταύνου	4	1.0			1.0		0.05	0.084	
Θηγαλίος	3	1.0			1.0			0.083	
Ψινεῖος	3	1.0			1.0			0.250	
ἀποτίσσος	3	1.0	1.8499049353136592E-5	1.0					
Θλαύσιος	3	1.0			1.0			0.134	
Τάσσηπος	3	1.0			1.0			0.114	
Τακτής	3	1.0				0.05	0.308		
Παθώντης	3	1.0			1.0			0.046	
Νεοκύλις	3	1.0			1.0			0.250	
Συζύγην	3	1.0			1.0			0.200	

Automated «Sprachgefühl» (text mining)



Automated «Sachkunde»?



Thank you for your attention!

