Artificial Intelligence and Greek Philology: An Experiment

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Artificial Intelligence and Greek Philology: An Experiment

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Table of Contents

Introduction
Luigi Battezzato, Barbara Graziosi, and Johannes Haubold 7

Part I: Artificial Intelligence and Greek Philology

1. Virtuous (and Vicious) Circles in Machine-Human Collaboration: The Case of Greek Philology
Barbara Graziosi 13

2. The End of Philology? Human and Artificial Intelligence
Luigi Battezzato 37

3. What is Artificial Intelligence Good For? A Philological Perspective
Johannes Haubold 59

Part II: An Experiment in Artificial Intelligence and Greek Philology

4. How Does Logion Work? An Introduction for Philologists
Creston Brooks and Charlie Cowen-Breen 97

5. How to Work with a Logion Report
Yuecheng Li and Johannes Haubold 109

6. The Potential and Limit of Logion Reports
Jakob Barnes and Maria Giovanna Sandri 135

7. Machines, Scribes, and Scholars: Comparing Human and Artificial Emendation
Olivia May and Leyla Ozbek 163

Introduction

This volume stems from a collaboration between researchers at the Scuola Normale Superiore in Pisa and at Princeton University: it began with a workshop held at Palazzo della Carovana in June 2023 and continued through the academic year 2023-24, as participants collaborated to present, in the form of the chapters collected here, an experiment at the intersection between artificial intelligence and Greek philology.

The general aim of this volume is to facilitate a conversation between the two fields it intersects, in the belief that machine learning can play a positive role in elucidating and preserving ancient and Byzantine Greek texts (and indeed premodern texts in many other languages too). We also believe that philology, with its commitment to preserve the most diverse, rare, and wonderful forms of human expression, transmitted by hand from the deep archives of the past, has a crucial contribution to make in the present moment, given that large language models trained disproportionately on contemporary English threaten to obscure the full diversity of human cultures and linguistic expressions.

Here we introduce readers to Logion, the first deep neural network designed to support philologists editing Greek texts that have reached us via manuscript transmission. The model offers suggestions for how to fill lacunae and emend portions of text that appear to have been corrupted in the process of copying texts by hand. Logion can also be used to identify textual corruptions that occurred at later stages in the history of textual transmission, being equally effective at recognizing scribal, typographical, and digitization errors. Further information about the model and the code used to train it can be found at https://www.logionproject.princeton.edu/. Editors of premodern Greek texts wishing to use Logion and needing assistance are encouraged to get in touch with us via the project website. We actively seek collaborators

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and are eager to finetune Logion to support work on specific authors, meters, periods, and genres. Please get in touch.

For the purposes of the specific experiment presented here, we focus on the oeuvre of the Byzantine polymath Michael Psellos (1018-after 1081?).. Our choice is based on three considerations. First, Psellos' writings are in need of philological attention: several editions are currently under preparation or in the process of being revised. The work presented here can therefore be of immediate utility to colleagues involved in those projects. Secondly, Psellos' own interests align with ours: he cared about clear and accurate expression (see e.g., *Ep.* 275.87-97). For this reason, working on his oeuvre is easier, for both humans and machines, than dealing with less disciplined forms of Greek. A third and important consideration is that Psellos is the author of a vast extant oeuvre: about one million of his words have been digitized. Language models are data-hungry and his work represents an easier case study than a smaller corpus would provide.

We would like to express our thanks to all participants in the workshop and to Dr. Silvia Litterio, who prepared this volume for publication. We would also like to thank the director of the Thesaurus Linguae Graecae, Professor M. Pantelia, for providing us with the TLG files containing the works of Psellos and for allowing us to use them for the purposes of machine learning. In return, our experiment shows that machine learning can support the TLG by improving the accuracy of its data. It is our hope that successful collaboration between human experts and machines will eventually make it possible to grant access to a full, accurate, and open archive of premodern Greek texts.

In preparing this volume, we sought to identify productive patterns of collaboration between humans and machines, for the purpose of preserving and elucidating the global archive of premodern texts, not just in Greek, but in many other languages too. The reasons why this is important are outlined in chapter one. Chapter two considers how the experiment at the heart of this volume relates to the history, practice and theory of Greek philology. Chapter three shows, by way of concrete example, how artificial intelligence can help philologists improve their work and achieve better results than they could do without it. Taken together, the first three chapters outline the broader intellectual context for the specific experiment presented in the second part of our volume. In chapter four, two machine-learning specialists present Logion, the deep neural network they designed to support work on premodern Greek texts. In the next three chapters, philologists assess Logion's outputs, thereby making contributions that help advance the

technological development of Logion and shed new light on the work of Michael Psellos.

We would like to thank the Humanities Council, the Center for Digital Humanities, and Princeton Language and Intelligence, as well as the Scuola Normale Superiore in Pisa, for supporting the work presented here. Last but not least, we would like to thank all participants in the workshop, together with Suma Bhat, Karthik Narasimhan, and Stratis Papaioannou for their advice.

Luigi Battezzato,
Barbara Graziosi,
and Johannes Haubold

Part I

Artificial Intelligence and Greek Philology

1. Virtuous (and Vicious) Circles in Machine-Human Collaboration: The Case of Greek Philology

Competition between humans and machines is an important feature of artificial intelligence as a field of research. Competition among humans is also a driving force in Greek philology. This chapter argues that the time has come to focus on collaboration and include artificial intelligence in pursuit of philology as a collective endeavor focused on elucidating and preserving the global archive of premodern texts. That task is urgent, particularly at a time when the increased use of large language models threatens to flatten human diversity of expression. Greek philology has a long track-record of valuing and protecting rare and unique uses of language, such as Homeric *hapax legomena*. Artificial intelligence can help extend the philological care devoted to such expressions beyond canonical Greek literature. To that end, this chapter outlines three virtuous (and associated potential vicious) circles in the exchange of ideas and practices between artificial intelligence and Greek philology. The first concerns the circulation of data. The second focuses on workflows. The third considers capacity building and the challenges of learning.

Keywords: Machine-human Competition; Machine-human Collaboration; Open Data; Philological Practice; Machine and Human Learning; Premodern Greek

We can approach the relationship between artificial intelligence and Greek philology by placing ourselves in one of the two fields and walking towards the other. The metaphor, however, has a temporal as well as a spatial dimension: artificial intelligence is a relatively new field; Greek philology, by contrast, seems old to the point of moribund. In chapter 2 in this volume, Battezzato asks whether philology is, in point of fact, dead and suggests two reasons for considering it a live concern. One is that many Greek texts, particularly those stemming from late antiqui-

Graziosi, B. 2025. "Virtuous (and Vicious) Circles in Machine-Human Collaboration: The Case of Greek Philology" in Battezzato, L., Graziosi, B., and Haubold, J. eds. *Artificial Intelligence and Greek Philology: An Experiment*, Pisa: 13-35.

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ty and the Byzantine period, still lack reliable editions. Another is that even well edited, canonical texts are not perfectly understood or established in their original form once and for all: the process of interpretation and therefore also of reconstruction is – as Battezzato insists – subjective and necessarily open to disagreement and debate. In addition, advances in linguistics, history, anthropology, not to mention imaging and computational technologies, affect how we understand and reconstruct imperfectly transmitted texts from the premodern world.

As for artificial intelligence, its status as a live concern – indeed as a current cause of concern – is hardly in question. If we consider its history, though, we realize that this is not especially recent and that the entire development of the field is characterized by human incomprehension and alarm. Once a computational tool is well understood and thoroughly integrated into human activities, it is often no longer perceived as intelligent at all. Historian of artificial intelligence Pamela McCorduck identifies a recurrent pattern from the 1950s to the early 2000s: "if you could see how it was done, people seemed to think, then it couldn't be intelligence".[1] She tells a story of advances in artificial intelligence and their subsequent, fitful naturalization into everyday use – at which point, rather paradoxically, artificial intelligence was said to have failed.[2]

Twenty years on from the 2004 edition of McCorduck's *Machines Who Think*, we find ourselves in a time of unprecedented wonder and alarm at the possibilities of artificial intelligence. Deep neural networks, in particular, have brought about huge advances in areas previously thought to be exclusively human, such as conversational skills, emotional awareness, or driving a car. The very language used to describe these networks is likely to cause alarm, though 'deep' simply refers to multiple layers in the architecture of a model and 'neural' refers to nodes in the model which connect to several other nodes, in a manner intended to resemble how neurons fire up and connect to one another in a human brain.

It is possible that this current moment of wonder and alarm at the achievements of artificial intelligence may lead to a calmer time in which AI tools are well integrated into human life. It is even possible that the work presented in this volume may contribute to that transition, by suggesting ways in which philologists may better un-

[1] McCorduck 2004: 423.

[2] McCorduck 2004: 423.

derstand and use AI tools in their work. That said, we are not there yet. We have made some preliminary inroads into the interpretability of our own model, Logion, by focusing on what is called 'attention' in the field of machine learning – i.e. by investigating which parameters are associated with learning which specific features of premodern Greek – but interpretability remains largely unsolved for Logion and for natural language processing more generally.[3] The process of integration of artificial intelligence is likely to follow different paths from full comprehension or predictability. After all, those qualities cannot be straightforwardly applied to human intelligence either: we do not know exactly how human brains work. What is happening at present is that the language used to describe machines – 'intelligence', 'learning', 'attention' – changes in meaning as we engage in an ongoing competition between humans and machines.

I offer just one example. Being good at chess used to be considered a sure sign of intelligence. When, however, an IBM machine called Deep Blue beat world champion Garry Kasparov in May 1997, that assumption changed. *The Economist* insisted: 'we now know that chess-playing skill does not, in fact, equal intelligence'.[4] In other words, intelligence was redefined to protect it as a uniquely human quality and the bar for computers was, as a result, set higher: machines could not be intelligent because they did not engage in conversation or read emotions – except that now they do. It is still tempting to dismiss computer activities as mere 'number crunching' – which is a correct description, of course, even if it prompts the question of what kind of number-crunching, or on-off neural activity, explains the human brain. In principle, we can reverse the line of our investigation and ask not whether machines can display true intelligence, but whether human brains are, in fact, computers. That too, unsurprisingly, depends on the definitions we adopt. We can quickly agree that a human brain is not a computer in the sense that it is mortal, biodegradable, and the result of biological evolution. There are then further questions about the extent to which neural networks in brains and in computers resemble each other – a point to which I return at the end of this chapter. For now, I make a more basic observation. If we define any device capable of implementing a variety of computable functions as a 'computer' – which, incidentally,

[3] Cowen-Breen et al. 2023a.

[4] Emmott 2003: 13.

is a standard definition of 'computer' in Computer Science – then 'the brain is not simply like a computer. It is literally a computer.'[5]

Clearly, one of the issues at stake is our use of words. Another is our openness to artifice and analogy – and our willingness to be impressed by what we create, especially when we do not entirely control it. In her expansive history, McCorduck links artificial intelligence to specifically Hellenic ways of thinking. She writes about the tendency, in Greek myth, to ascribe anthropomorphic qualities to gods and automata, emphasizing the artificiality of Pandora, who then nevertheless acts according to her own plans, and the human vanity involved in falling in love, like Pygmalion, with one's own human-like artifice.[6] McCorduck contrasts the tendency to extend the anthropomorphic beyond the human with the Hebraic proscription against graven images, which she presents as a warning against confusing representation with the real thing.[7] All this is a simplification along the schematic opposition between Hellenic and Jewish roots – an opposition that can and has been called into question. Still, conceptually, many of the issues raised by artificial intelligence have ancient origins, even if, as a field of research, it emerged only recently.

The birth of artificial intelligence, as a field of academic enquiry, can in fact be pinpointed with precision. In 1956, four scientists – John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon – submitted an application to the Rockefeller Foundation, asking support for 'a two-month, ten-man study of artificial intelligence [...] on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.'[8] The application was successful and the now legendary 'Dartmouth conference' had two lasting consequences. The first was that it helped define artificial intelligence as a field of enquiry, by postulating the fundamental hypothesis it seeks

[5] Falk 2021, quoting Blake Richards.

[6] McCorduck 2004: 4-6. Hesiod's account makes it clear that once created, Pandora used her scheming mind to pursue her own nefarious ends: ἀνθρώποισι δ' ἐμήσατο κήδεα λυγρά ('she planned terrible evils for men', *WD* 95).

[7] McCorduck 2004: 7 recognizes that the labels she uses, Hellenic and Hebraic, 'are a historian's convenience to describe two casts of mind, and don't address the evolution of living cultures or religions', let alone exhaust ancient reflections relevant to current developments.

[8] McCorduck 2004: 111.

to test. The second was that the language adopted, specifically the language of 'intelligence', provoked humanist reactions, thus launching a game of one upmanship and shifting goalposts. Every advance in artificial intelligence was met with a redefinition of what counted as true intelligence and the eventual relegation of machines to a subordinate role. In chess, for example, computers briefly destabilized notions of 'intelligence' before settling for roles in analysis and training, by now competing in machine tournaments that interest only a small number of human specialists. Meanwhile it is the human players who continue to grab the headlines, even though they cannot hope to beat champion machines like Stockfish or AlphaZero.

In philology, we are still a long way away from having computers outperform human experts. For one thing, philology is too varied and multiform a field to be reduced to a game with a straightforward outcome, a winner, a loser, or a draw.[9] In order to define philology in that manner, we need to reduce it to specific and measurable tasks: lacuna filling is the most obvious, because it is possible to create a fake lacuna that accurately mimics real ones (by masking random portions of text) and we can then ask a philologist and a machine to guess what is missing. Machine and human conjectures can be checked against what computer scientists call 'ground truth', and philologists call the 'paradosis', i.e. the transmitted text. We can then establish who wins, or gets it right, more often. As Brooks and Cowen-Breen explain in chapter four, we first conceived of Logion precisely as a model that would make suggestions for lacuna-filling. We then set up an experiment in which we measured human vs machine success at that task; more importantly, we measured success for human-machine collaboration, establishing that the best results were obtained when a human expert had access

[9] In the field of machine learning, there is an increasing focus on developing models that can match human general intelligence. One aspect of this effort concerns the need to develop benchmarks for measuring the performance of such models: "Humanity's Last Exam", a dataset of 2,700 challenging questions across scores of different fields of human learning (https://agi.safe.ai/), is one attempt to answer that challenge, see Phan et al. 2025. Another way might be to focus on a complex philological problem that can be only be approached by mobilizing different kinds of knowledge and forms of intelligence, for example, historical, anthropological, geographic, ecological, etc., as well as linguistic. The philological challenges described by Battezzato in chapter 2 in this volume are currently very far from admitting machine-generated answers.

to machine-generated suggestions for lacuna-filling.[10] This is in line with a similar evaluation of Ithaca, a model designed to restore, place, and date Greek inscriptions: in terms of performance measurements, its creators modelled an approach that inspired our own.[11]

It is harder to quantify machine, human, and machine+human success for the second philological task on which we focused, namely that of detecting and emending portions of text that were corrupted in the process of textual transmission. This is because we do not necessarily have the transmitted text, or ground truth, in the case of textual corruptions and we cannot have full confidence in our ability to create artificial scribal errors, in all their complexity and variety, in order to test the success of machine, human and machine+human attempts at detecting and emending them. Nevertheless, there are ways to make plausible simulations and assessments for this task too.[12] In fact, one of the purposes of this volume is to develop, collaboratively, robust ways of doing so by using actual scribal errors, rather than simulations.

Competition between humans and machines has been an important feature of artificial intelligence as a field. Competition among humans also plays a large role in Greek philology, as Battezzato points out in chapter two. That said, there is a way of conceiving of philology as 'a collective effort', to quote Sebastiano Timpanaro, one of the most acute theorists as well as practitioners of classical philology.[13] Specifically, he argues that conjectures are most trustworthy when they occur independently to different editors, rather than stemming from the original work of a single human mind.[14] A similar conception of philology animates the present volume, even if we widen our philological community to include machine suggestions. To support that inclusion in what has been, up to now, a profoundly humanist area of research,

[10] Cowen-Breen et al. 2023b. This is an approach we learned from Assael et al. 2022.

[11] Assael et al. 2022.

[12] Cowen-Breen et al. 2023b.

[13] Timpanaro 2003: 7.

[14] This aspect of Timpanaro's thought is explored in detail in Geue 2025. Some of its claims are anticipated in Geue 2023: 'in Timpanaro's account, the history of philology became a gradualist process involving the work of many unacknowledged hands over several centuries, rather than the sudden eureka-style spark of a single revolutionary light bulb. The notion that intellectual history was not linear, but full of cases of people who had 'got there first', became crucial in Timpanaro's own cultural politics, constantly looking as he did to the past to furnish progressive examples for the present'.

I outline three virtuous (and associated potential vicious) circles in the exchange of ideas and practices between artificial intelligence and Greek philology. The first concerns the circulation of data. The second focuses on workflows. The third considers capacity building and the challenges of learning.

Circle One: Data

Computer models can only ever be as good as the data on which they are trained. ChatGPT, to take one example, 'exhibits a strong alignment with American values, but adapts less effectively to other cultural contexts [...] flattening out cultural differences'.[15] The abundance of English-language training data explains this general trend, while also accounting for bias against rare and non-standard uses of English. A recent study shows, for example, that ChatGPT and other commercial chatbots exhibit prejudice against speakers of African American English – and this even after receiving specific anti-Black-racist training; that training, in fact, results in a tendency to express superficially positive sentiments toward African Americans, while discriminating against them in ways that reduce their employability and have other detrimental effects in real life, given that chatbots are now increasingly used for the initial screening of job applications, for example.[16]

There is an urgent need, in the field of artificial intelligence, to find ways to honor and protect minority languages and uses of language. In relation to that goal, it seems to me that philological research can play a helpful role: editors of ancient texts have long been concerned to protect rare premodern languages, and even rarer premodern words and expressions. Already in antiquity, scholars made lists of Homeric words and expressions that were 'said only once', *hapax legomena*: as well as protecting such words, those lists helped to normalize the idea that unique expressions not only existed but deserved attention and celebration.[17] To this day, philology pays attention to the *lectio difficilior*, the difficult manuscript reading that is liable to have been sim-

[15] Cao et al. 2023.

[16] Hofmann et al. 2024. The type of anti-Black racist training provided is known as RLHF (Reinforcement Learning from Human Feedback); for a review see Chaudhari 2024. On the problem of toxicity in ChatGPT, see also Deshpande et al. 2023.

[17] On the practices and values of ancient literary scholars, Pfeiffer 1968 is still use-

plified, or standardized, in the course of textual transmission.[18] This philological care for what is rare, and in danger of being forgotten or sidelined, speaks to our present moment. It needs to inform collaboration across the fields of artificial intelligence and Greek philology. More generally, machine learning in many different fields needs to develop better ways of honoring and protecting minoritarian languages and non-conforming uses of language.

There are many ways to work towards that goal. One step is to ensure that machines can train on historically deeper and more diverse datasets than currently available. At present, many premodern texts are not digitized at all – and even those that are may not be open access. Premodern Greek texts are better edited and digitized than most – and yet they too are unavailable in good digital editions. The largest and most reliable digital archive, the Thesaurus Linguae Graecae (or TLG), is not as reliable as the best printed editions and offers no guidance on gaps or scribal errors (such information is still almost exclusively contained in expensive printed books). Moreover, the TLG itself is hidden behind a pay wall.[19]

This means that the most exhaustive and accurate digital collection of premodern Greek texts is unavailable to machine learning. Tools like Logion would greatly improve their performance if they could train on better and larger datasets than currently possible. In turn, however, they could be used to improve our understanding of premodern texts and, hence, the accuracy of digital archives such as the TLG. This is the first virtuous circle presented in this chapter.

I offer here just one small example of machine-driven improvements in human understanding, though this volume contains many more. As explained in greater detail in chapter four, Logion is trained to flag portions of text where it suspects that something may have been garbled in the course of transmission. Twice, in a poem by Michael Psellos, *In obitum Scleraenae*, Logion flags the unusual form φιλάτη (supposedly meaning 'dearest', in the feminine) and suggests that it should be replaced with the standard φιλτάτη. A quick check in Westerink's

ful. Nünlist 2009 and Schironi 2018 do not have the same sweeping breadth but offer much more detailed and up-to-date accounts.

[18] West 1973, see esp. 51 on the important difference between 'a more difficult reading and a more unlikely reading'.

[19] The Thesaurus Linguae Graecae can be accessed here, via subscription: https://stephanus.tlg.uci.edu/.

Teubner edition of the poem confirms φιλάτη, once in the vocative, once in the dative: unlike other instances flagged by Logion, these errors did not occur in the process of digitizing that edition for inclusion in the TLG.[20] Now, if we click on those forms, the TLG lexicon gives us the information that φιλάτη is a rare Byzantine form of the standard feminine superlative φιλτάτη. However, prompted by Logion, we checked two of the three manuscripts consulted by Westerink and established that they actually read φιλτάτη, as can be seen in Figures 1a-b and Figure 2 (we did not have access to the third manuscript, Firenze, Biblioteca Medicea Laurenziana, Conventi soppressi 627). What we have here, then, is an error in reporting manuscript readings.

Figg. 1a-b and 2. Prompted by Logion, we note that in Psellos' poem 17, *In obitum Scleraenae,* lines 172 and 234, two of the three manuscripts that transmit the poem read φιλτάτη – not φιλάτη, as printed in the Teubner edition and reproduced in the TLG. (We could not check the third manuscript.) On the basis of these misread passages in Psellos and a third instance in Anastasios Gordios (also an error), the TLG lexicon claims that φιλάτη is a Byzantine form, rather than the result of modern mistakes.

Here we see how an error in a modern edition was transformed by philologists into a rare Byzantine form. In this case, the tendency, on

[20] Westerink 1992.

the part of machines, to privilege what is statistically most likely leads to checking the manuscripts and reading them correctly.

There are many other cases, however, where machines could learn from unlikely uses of language. Michael Psellos, for example, occasionally describes himself as having a female soul inside a male body.[21] When prompted to identify the earliest occurrence of such a statement, ChatGPT points to Chevailer d'Éon in the eighteenth century (Figure 3), though Psellos provides evidence for such self-description in the eleventh century. There are many reasons for Psellos' lack of impact here. Among these, the first and most fundamental is that his autobiographical works are simply unavailable, open access, in digital form. In short, they do not exist, as far as machine learning is concerned. They also do not exist as far as English readers are concerned, because they have never been translated. Again, the task of translation would benefit from machine input. I note here that even models that perform better than ChatGPT at this kind of general-knowledge question would not be able to arrive at Psellos: this kind of knowledge is currently quite simply not accessible to machines.

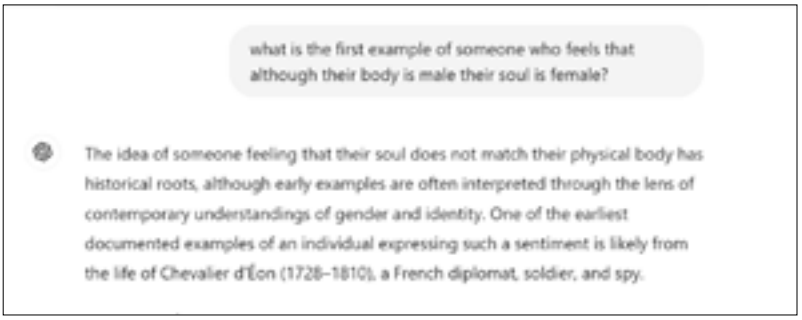


Fig. 3. ChatGPT, accessed in July 2024, claims that one of the earliest examples of someone thinking of themselves as having a female soul in a male body dates to the eighteenth century. Psellos describes himself in those terms in the eleventh century. It is possible that, as a result of our work on Psellos and, more generally, our collective intent to open up the archive of premodern texts, answers to questions of this kind will become more accurate.

Philologists tend to draw a sharp distinction between proper editions of premodern Greek texts (which have an *apparatus criticus* but

[21] See, for example, *Ep.* 128.29-41 and *Ep.* 306.19-20, with Papaioannou 2013: 192-231.

no translation) and editions intended for a broader readership of students, teachers, and the general public (which include facing translations but usually give little or no information about textual problems). In the digital humanities, the TLG is used regularly for the purpose of preparing critical editions (even if it does not itself include a text-critical apparatus), while Perseus Digital Library serves more general needs by offering a narrower selection of texts accompanied by out-of-copyright translations.[22] My point here is that it would be helpful to move beyond this notional division between expert and general readers and ensure that a much wider range of premodern Greek texts becomes available in digital form, open access, and accompanied by working translations.[23] Artificial intelligence can help achieve this goal – but only if we begin by assembling a large enough dataset, something on the scale of the TLG, and make it open access.[24]

Circle Two: Workflows

In addition to the challenge of making historically and linguistically more diverse data available to machines (and using machines to make such data more easily accessible and comprehensible to humans), we need to establish better working relationships between machines and human experts in the restoration of premodern texts. To do so, we can begin by asking what counts as good work in each of the fields involved in our experiment, artificial intelligence and Greek philology. When it comes to evaluating computational models, success is generally statistical. We have already seen an example of this when I summarized how we evaluated Logion for the task of lacuna filling: does the model perform better than a human being when we mask a portion of text that has actually been transmitted? Does a human being with access to Logion suggestions perform better than without? These seem straightforward questions but, in fact, there are several problems lurking just below the surface of what seems to be an objective approach.

[22] It can be accessed here: https://www.perseus.tufts.edu/hopper/.

[23] See also Graziosi et al. 2023.

[24] DeepSeek-R1, an open-source model from China, recently made the headlines for beating state-of-the art models from closed source companies (OpenAI, Google) by using a new method for reinforcement learning – at seemingly a fraction of the cost. This victory bodes well for open-source approaches. See Guo et al. 2025.

One obvious difficulty is which human being we may want to pitch against a model. Tasked with evaluating Ithaca, its creators measured machine success against the performance of 'two graduate students in ancient history'.[25] That hardly seems fair to humans, given that students are by definition still in the process of training, but the problem would persist even with the involvement of world-recognized specialists in Greek epigraphy. There is, in fact, no universally recognized Kasparov in the study of ancient texts, quite simply because philology is a varied, subjective, and collective endeavor. Widespread engagement with computational models on the part of several human experts is therefore key. And here we must confront a curious fact. Ithaca garnered enormous attention in the media, making it to the frontpage of *Nature* on March 9th, 2022: according to the experiment set up by its creators, it surpassed human beings (or: the two human beings involved in the experiment) at filling lacunae in Greek inscriptions, even if humans could then further improve on machine-generated results once they had access to them. The question I wish to ask here is simple: if Ithaca is so successful, why are professional scholars not making more use of it? Why has the model not become part of their regular workflow?

It may be tempting to blame the conservatism of scholars engaged in the study of ancient texts, but that is not a sufficient explanation. Those who devote their lives to restoring premodern texts will adopt any new tool or method – should it prove to be genuinely useful. In other words, adoption and use, in addition to statistical evaluation, should count as a measure of success. That, in turn, means it is important to publish significant results, in order to make the case for artificial intelligence in the field of Greek epigraphy and, more generally, Greek philology.[26] To encourage use, it is also important to enable scholars with no training in computing to use tools like Ithaca and Logion. Neither is, at present, especially user-friendly. That said, a more accessible front-end design would not necessarily increase adoption. In fact, it could jeopardize the reputation of artificial intelligence among human experts, should a tool prove easy to use but underwhelming in output. In the case of Logion, there is no doubt in my mind that further development is more urgent than front-end design.

The main point I want to make here is that, to ensure further development, we need to consider what counts as success not just in arti-

[25] Assael et al. 2022: 286.

[26] That was one of the stated aims of Graziosi et al. 2023.

ficial intelligence, but in Greek philology. That is best understood in relation to its main goal, that of 'making sense of texts', in Pollock's straightforward definition, and in relation to philological workflows.[27] To start with those, philologists usually begin by reading carefully. If they plan to make a critical edition of what they are reading, they consider the possibility that something might have gone wrong in the transmission of a premodern text, asking whether the scribes responsible for copying it missed some words, or misspelled, or filled in, or modernized, or simplified what they were themselves reading and copying. When different manuscripts of the same text survive, philologists pay particular attention to variant readings, trying to evaluate them and account for their origin. Once textual problems are identified through reading, philological workflows can be roughly divided into two further stages, well described by A. E. Housman in an article published over one hundred years ago.[28] After the identification of textual problems, there needs to be a degree of philological intuition to conjecture what might have gone awry in the process of transmission. Next, conjectures need to be subjected to careful scrutiny. Computational advances have transformed that last part of the process: editors now check emendations and supplements via TLG searches and other forms of corpus analysis. However, when it comes to the earlier stages of the work, practices have hardly changed since the time of A. E. Housman.[29]

In the account offered by R. G. M. Nisbet, himself an outstanding philologist as well as a self-declared admirer of Housman, the best conjectures pop up while 'on holiday, when one feels no obligation to be busy, and the relaxed mind summons up and integrates things long forgotten. The period after Christmas is particularly productive, when everything is shut and one is slouched in an armchair half-asleep. The Muse of Textual Conjecture (let us call her Eustochia) only visits those who have worked, but she does not visit us when we are actually working.'[30] Apart from noting, with Scognamiglio, the whiff of elitist, leisurely self-regard in this image of the scholar at rest, the point I would

[27] Pollock 2009: 934.

[28] Housman 1921.

[29] On the separate stages of conjecturing and justifying the conjecture, see also Battezzato 2019 and 2021.

[30] Nisbet 1991: 91.

like to make here is that artificial intelligence can help, should Eustochia fail to show up after Christmas.[31]

As several articles in this volume demonstrate, Logion can identify portions of text that seem problematic and suggest ways to emend them. At present, two difficulties prevent philologists from taking advantage of the insights it provides. The first centers on the problem of persuasion: experts need to be convinced that machine-generated suggestions are of good enough quality to justify the adoption of new methods. The second difficulty, again in human terms, is ease of use. Philologists generally have no expertise in machine learning: any computational tool designed to assist them needs to be user friendly. Roughly speaking, in technological terms, these two issues relate to model performance and front-end design.

Model performance needs to be addressed first, for reasons that have already emerged. If an instrument like Logion is easy to use, but produces poor results, it will quickly be dismissed. In fact, it may lead philologists to conclude more generally that machines cannot offer meaningful assistance in making sense of texts. To improve model performance, we need to measure success – and here human feedback on machine-generated results (feedback of the kind provided in this volume) is of the *utmost* importance, for at least two reasons. The first is that publishing philologically significant results can help make the case for using tools like Logion. The second is that once we have enough human assessments of machine-generated results, it is possible to ask a machine to learn from those assessments and indeed use them to benchmark machine performance.[32]

Ideally, it would be good if Logion were able to identify textual problems that have escaped the attention of human editors *and* offer convincing conjectures for how to emend them. Human editors would then still have the task of justifying why those conjectures are, indeed, convincing, but the first two phases of the philological workflow would be transformed. Now, it must be said that Logion rarely identifies textual problems and straightforwardly solves them. More often it points to modern misreadings and mistakes (such as φιλάτη); unconvincing editorial decisions in the face of variants; typographical errors; or digitization mistakes. Still, occasionally, it does offer something that

[31] Scognamiglio 2021 carefully traces various allusions to famous philologists (Bentley, Ruhnken, Housman) contained in Nisbet's portrait of the scholar (not) at work.

[32] See Brooks et al. 2025.

genuinely impresses. Figure 4 shows how Logion-generated results are currently formatted. Flag 289 suggests that the word οἴκοι ('at home') should in fact read οἴμοι ('alas'). With this information, it is possible to search the TLG, find the relevant portion of text, translate it, and finally arrive at an assessment of Logion's suggestion (a cumbersome process we are currently streamlining).

Fig. 4. Flag 289, in a Logion report as currently formatted, suggests that the word οἴκοι ('at home') should in fact read οἴμοι ('alas'). The report refers to [Psellos] poem 62, *In scabiem,* line 62. Here Logion identifies a previously undetected textual problem and offers a convincing emendation.

The text in question is poem 62, *In scabiem*, in which a certain Michael (not necessarily Psellos)[33] wishes scabies on a man who mistreated him in his youth (62.53-62):

κόμης τίς ἐστι, τὸν χρόνον κατὰ Κρόνον,
ὃς ἐν ναῷ πάλαι με τῶν Ἀποστόλων
θέλοντα πομπὴν τὴν βασιλέως βλέπειν
ἀνηλεῶς ἔτυπτε (φεῦ μοι) τῷ ξύλῳ,
ὤμους, κεφαλήν, ὦτα, πλευρὰς καὶ σκέλη
παίων ἀφειδῶς, πᾶν μέλος μοι συντρίβων.

[33] Westerink 1992: 429 doubts authenticity, arguing that Michael Psellos adopted the name Michael on becoming a monk and that a monk would not have been so brutally treated.

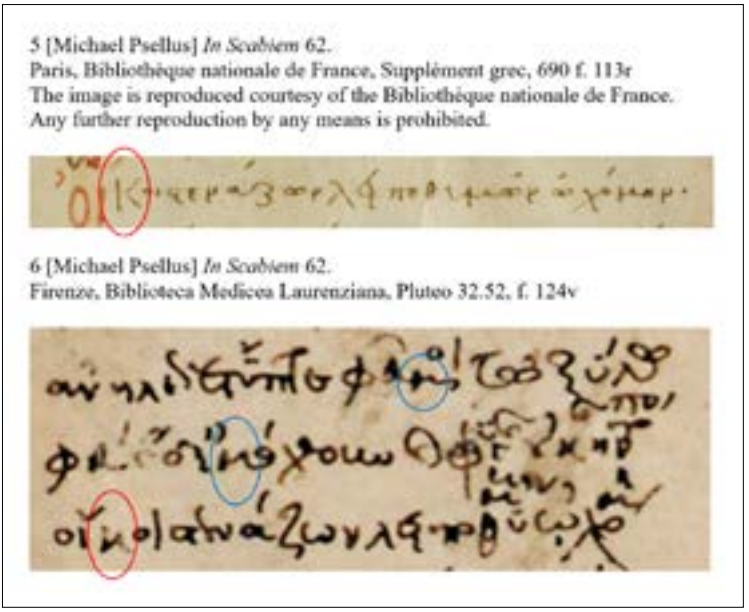
φεύγειν δ' ἐμόχθουν καὶ φυγῆς οὐκ ἦν τόπος,
ὥσπερ ποταμοῦ πλημμυρούντων τῶν ὄχλων,
ἕως ἀπειπών, ἡμιθνής, βραχὺ πνέων,
οἴκοι στενάζων, λειποθυμῶν ᾠχόμην.
He is some sort of count, a man as old as Kronos,
who once, long ago now, in the Church of the Apostles,
gave me a brutal hiding with a stick, poor me,
while I was standing there, hoping to watch the king's procession.
He worked my shoulders, head, ears, ribs, and legs,
without mercy, crushing my every limb!
I did my best to get away but there was no room to escape,
because the crowds were pressing on like a river.
Eventually, defeated, half-dead, and barely breathing,
wailing **at home** and almost fainting I got away.

It must be said that οἴκοι does not make much sense in context. Poor Michael, at this point in the narrative, is not at home, but still in church, and the verb he uses to describe his own wailing (στενάζων) has tragic resonance, so adding an 'alas', οἴμοι, would fit well.[34] In fact, Logion's suggestion makes so much sense that, on first seeing the report, our assumption was that οἴκοι must be a digitization error in the TLG, or possibly a typographical error in the Teubner edition, much like φιλάτη.

In this case, however, the manuscripts do in fact read οἴκοι, as shown in Figures 5 and 6. So what we have here is a case where Logion successfully performs the first two phases of a well-established philological workflow. It seems to me that Logion identifies a genuine case of textual corruption and convincingly emends the text. A search of the TLG provides a good parallel: Constantinus Stilbes, describing the fire

[34] More generally, *In scabiem* is mock-tragic, and explicitly so, see esp. 10-11:
Οὐκ ἔστιν οὐδὲν δεινόν, ὦδ' εἰπεῖν, πάθος
χεῖρον, τραγῳδέ, κνησμονῆς ψωραλέας.
There is no dreadful suffering, so to speak,
worse, o tragedian, than itchy scabies.
The lines rework the opening of Euripides' *Orestes*:
Οὐκ ἔστιν οὐδὲν δεινὸν ὦδ' εἰπεῖν ἔπος
οὐδὲ πάθος οὐδὲ ξυμφορὰ θεήλατος,
ἥς οὐκ ἄν ἄραιτ' ἄχθος ἀνθρώπου φύσις.
There is nothing dreadful, so to speak,
neither suffering nor god-sent calamity,
whose burden human nature will not bear.

that ravaged Constantinople in 1197 CE, writes in *Carmen de incendio*, 1.925f. οἴμοι στενάξω τοῖς ἀλαλήτοις γόοις / ἕως ὁρῶ πῦρ, τὴν φθορὰν τῆς πατρίδος ('alas, how I shall wail with loud laments as long as I see the fire, the destruction of the fatherland').



Figg. 5 and 6. At line 62 of *In scabiem*, the relevant manuscripts read οἴκοι, as shown by the red circles. The blue circles show that the letters μ and κ are sometimes hard to distinguish: this may be one of the reasons for the scribal error identified via Logion, but there are also other and more compelling considerations that help explain the genesis of οἴκοι ('at home') for οἴμοι ('alas'). Various glosses suggest that οἴμοι was not in common use and the scribe may have been in a rush to place Michael safely 'at home', after his ordeal.

Perhaps the passage in Constantinus Stilbes played a role in the emendation proposed by Logion, but we cannot know: Logion is essentially a black box. It cannot justify an emendation, as I have just done, by reference to the situation being described, or the influence of Greek tragedy. Likewise, it cannot explain why οἴμοι might have become οἴκοι. Future 'general intelligence' models might perhaps be able to do that and, in fact, this kind of philological problem would be a good test-case for assessing their performance.[35] Three consid-

[35] This is the kind of problem that could be added to the dataset in Phan et al. 2025. See above, n. 9.

erations may help account for the corruption: one paleographic, the second lexical, and the third, as it were, psychological, or even a matter of human embodiment. As the second manuscript in Figure 6 shows, some hands write μ and κ almost indistinguishably, so it is possible that the scribe misread the text he was copying. This misreading may also reflect the fact that οἴμοι was not in everyday use, but rather represented elevated diction.[36] It also seems to me that the scribe may have sympathized with Michael's predicament and rushed him home rather too quickly, and at the expense of proper grammar, to protect him from the blows that were raining down on him.

Examples of the kind I have just given help to illustrate the benefits of using artificial intelligence to restore premodern texts – while also showing all the different kinds of human reasoning that need to go into solving philological problems. Machines are still far from displaying that kind of general intelligence and knowledge base. The point, for now, is simply that we need good *enough* machine performance, to justify the effort involved in working with a model like Logion. To address the issue, I propose the following virtuous circle. By publishing philologically significant results, we make the case for instruments like Logion. It is already clear that the model is capable of identifying previously undetected textual problems and that it can propose solutions to genuine difficulties. Once philologists begin to work with Logion, they are in a position to offer assessments of its results. Thanks, not least, to the work done in preparation for this volume, we now have a sufficiently large database of such assessments to offer feedback to Logion and let it train on its own successes and failures as assessed by humans.

We can also use our database of human assessments to measure the performance of different model architectures: a preliminary study we have just completed suggests that ELECTRA may be more effective than BERT at detecting scribal errors.[37] At a more detailed level, we can recognize recurrent problems and devise algorithmic solutions.

[36] We find οἴμοι also in line 56 of *In scabiem*, at least according to Paris, Bibliothèque nationale de France, Supplément grec 690, dating to the late eleventh century: ἔτυψαν οἴμοι. The later manuscript that preserves the poem (Firenze, Biblioteca Medicea Laurenziana, Pluteo 32.52) from the fourteenth century, reads ἔτυπτε φεῦ μοι (and Westerink adopts that reading in his edition). It seems that οἴμοι was often glossed with the more common φεῦ μοι, see e.g., schol. to Aristophanes *Wealth* 389 and 1125, a consideration that would militate against Westerink's editorial choice.

[37] Brooks et al. 2025. For ELECTRA, see Clark et al. 2020.

For example, as a result of the work presented in this volume, we now know for sure that a recurrent problem in Logion-generated results is the outsized influence of very common words.[38] Making use of TF-IDF (Term Frequency Inverse Document Frequency), a metric designed to address this kind of problem, is likely to improve results.[39] So much for my second virtuous circle, involving a productive workflow between humans and machines. The corresponding vicious circle is, unfortunately, all too easy to envisage: if artificial intelligence produces underwhelming results in the eyes of human experts, they see no reason to engage with computer models. Worse still, human expertise may be sidelined altogether, with terrible consequences. Already now, there are publications in reputed outlets that falsely claim machines are better than human beings at restoring ancient texts.[40] Should such claims be widely believed, we would initiate an alarming vicious circle: texts allegedly restored with the help of AI tools (which, by virtue of their training, tend to abhor the *lectio difficilior*) would be used to train the next generation of AI tools, resulting in an ever increasing falsification and banalization of the historical record. I note that this is already a recognized problem for Large Language Models initially trained on human-generated texts but now feeding on texts generated by artificial intelligence, i.e. as one peer reviewer of this volume put it, their own 'slop output'. In subsequent iterations, AI generated texts cannot but become ever sloppier. The incomprehension between philologists and machine-learning experts may be thought not to matter much – just one more example of failed interdisciplinarity among many – were it not for the fact that making sense of premodern texts is an under-resourced and crucial task (also, as we have seen, in the face of ever-increasing focus on what is statistically most likely). There is, then, a need to build capacity.

Circle Three: Capacity Building

Experts in brain network dynamics, in collaboration with computer scientists, have recently argued for a key difference between artificial

[38] The problem is systematically addressed by Li and Haubold in chapter 5 in this volume.

[39] See Wu et al. 2008.

[40] Assael et al. 2022.

and human intelligence. Models like Logion learn by a method known as backpropagation, or gradient descent, as Brooks and Cowen-Breen explain in greater detail in chapter four. What this means is that Logion attempts a task, learns from its successes and failures, and adjusts its parameters to increase its success rate. Some have argued that the brain learns in a similar way, but this has recently been called into question. It now appears that the human brain first settles its neural activity into a configuration that aligns with a prediction, and only then adjusts synaptic connections.[41]

I mention this new study because it seems relevant to many of the issues raised in this chapter. First, while we cannot reconstruct exactly how a model like Logion arrives at the suggestions it produces, this is also true of human philological reasoning. There is a black-box problem with models like Logion, to be sure, but a human philologist slouched in his armchair 'in the period after Christmas' seems equally inscrutable. In short, we do not know exactly how the human brain works, just as we cannot reconstruct exactly through which pathways Logion arrives at the results it produces. New insights into the neurological activity of the brain may in fact suggest ways to build better models. Vice versa, as we study machine-learning models and their outputs, we may become more aware of our own patterns of thought. As Haubold argues in chapter three, artificial intelligence can sometimes help to correct human bias precisely because, at least for now, it works differently and on the basis of different data.

Secondly, if indeed the human brain first settles into a configuration and then adjusts connections to minimize error, this would help to explain why we do not necessarily forget old knowledge when we learn something new. The point here is that 'the undesired and unrealistic side effects of learning with backpropagation are closely related with the phenomenon of catastrophic interference, where learning a new association destroys previously learned memories'.[42] In the study I summarize here, the problem is illustrated via the 'intuitive example' of a bear not forgetting the link between the sound of rushing water and salmon on account of a temporary ear infection, but rather adding the knowledge that sight of a river still promises lunch, occasionally also without sound effects. If we are willing to extend our intuition beyond this survival-focused example to broader cultural practices, we

[41] Song et al. 2024.

[42] Song et al. 2024: 349.

may have new ways of understanding the humanist impulse to preserve old knowledge. Such knowledge may, in fact, help 'to rapidly adapt to changing environments'.[43]

The task of preserving the global archive of premodern texts, by making it accessible and more easily intelligible to present and future generations of humans, is daunting. This volume focuses on premodern texts in Greek only, but one uplifting consideration is that the methods piloted here can be used for other premodern languages and archives too. *Simtho*, the Thesaurus of Classical Syriac, is a good candidate for capacity building of this kind.[44] At the moment, that archive collects texts digitized by Optical Character Recognition and then corrected by hand: Logion could, at the very least, direct human attention to portions of text that are unlikely to have been digitized correctly. The more general point here is that artificial intelligence can help us move away from zero-sum struggles for attention and resource in the study of premodern texts. Focus on canonical Greek can help develop effective approaches for the task of 'making sense of texts' also for late antiquity and the Byzantine period. Machine-learning methods can moreover be applied to other languages, provided we have sufficient training data.

The virtuous circle needed for capacity building would work as follows. First, we need sufficient data to train a model in a specific language, in our case premodern Greek. Then we need good patterns of collaboration, between humans and machines, to achieve the best possible results and, in the process, further train both machines and new generations of human philologists, as is happening in this volume. And, finally, we need to share algorithms and human insights so that new knowledge can help preserve old texts. Conversely, the idea here is that old knowledge can improve our human (and machine) capacity to learn new things.

[43] Song et al. 2024: 354.

[44] Simtho is available, open access, here https://bethmardutho.org/simtho/. In our view it already has sufficient data to train Logion in classical Syriac. Logion in turn would speed up the process of adding data (i.e. texts) to the Thesaurus, and improve its accuracy too.

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Barbara Graziosi

2. The End of Philology? Human and Artificial Intelligence

This chapter discusses how artificial intelligence impacts how classical philologists see the goals of their discipline and their own activities. The first section discusses the possibility, notably discussed by Nietzsche, that classical philology will at some point end. This is in turn linked to the idea that it is possible to produce definitive editions of classical texts. The debate between Pasquali and Romagnoli, in the years 1917-1920, highlighted the need to focus philological activities on texts that were not central to the canon, avoiding texts which already received supposedly definitive editions. The chapter argues that subjectivity is a central element of the philological practice. It also argues that philologists often present their conjectures as a way to access the subjectivity of ancient writers. Wilamowitz even suggested a religious explanation, derived from Plutarch's daemonology. The rhetoric of presenting a conjecture is often based on the concepts of truth, certainty, finality. Conjectures immortalise their authors. An AI 'conjecture' is deeply subversive of the religious and immortalising language of classical philology outlined here. However, AI can be extremely helpful in editing a large number of non-canonical texts that still lack reliable editions.

Keywords: Artificial Intelligence; Classical Philology; Textual Criticism; Wilamowitz; Pasquali; Ancient Greek; Premodern Greek

1. *The End of Philology*

Has the philological study of the Greek and Latin classics come to an end? Philology has been declared dead for over a hundred years.[1]

[1] This first section revisits some of the ideas which I presented in Battezzato 2023.

Battezzato, L. 2025. "The End of Philology? Human and Artificial Intelligence" in Battezzato, L., Graziosi, B., and Haubold, J. eds. *Artificial Intelligence and Greek Philology: An Experiment*, Pisa: 37-57.

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Yet, in the 19th century it was considered the queen of the sciences.[2] It was certainly the dominant approach in the humanities. Philology was not thought to be limited to textual criticism, but included the study of manuscripts, the interpretation of texts, and more generally of literature and civilisation. In French and English (but not in Italian), it also included the study of languages.[3] The attacks on philology had both political and scientific motives.

At the beginning of the 20th century, many scholars, especially in the countries that fought against Germany in the First World War, began to challenge the status and importance of philology. Some of them were motivated by political chauvinism: they felt they had to take a stand against the (German) philological enemy.

Part of the problem, however, was related to the nature of the discipline: was there a future for philological studies? The philological enterprise, if 'philology' is used strictly in reference to textual criticism, is based on the collection and interpretation of evidence. At the beginning of the 19th century, it seemed like a vast undertaking. The new methods, inspired by A.W. Wolf, A. Boeckh, and K. Lachmann,[4] required that all ancient texts be edited anew. All the manuscripts of ancient texts had to be read, collated, and organised into a stemma, before 'scientific' editions could be published; all the inscriptions of antiquity had to be transcribed, catalogued, and published. The 'field'

[2] Kurtz 2021: 752; Turner 2015: x ('king of sciences'); see also Pollock 2009: 939 "Hindustan, where philology –rather than mathematics or theology – had always been the queen of the disciplines". Until the 19th century, the queen of the sciences was theology: van den Brink 2019: 450. Foucault 1970: 281-2 claims that "the birth of philology has remained much more hidden from Western consciousness than that of biology and that of economy", in spite of the fact that "its consequences have extended much further in our culture"; by philology Foucault actually means comparative linguistics (especially Indo-European comparative linguistics).

[3] See e.g., Watkins 1990, Pollock 2009, Daston and Most 2015 (esp. 370 n. 1 "By 'philology' we mean, in the present context, the rational, disciplined, and institutionalized form of interpersonal research, testing, and communication, directed to (above all, written) texts [...]. We take 'Classical scholarship' in a broader sense – essentially that of Friedrich August Wolf and August Boeckh – to include all the disciplines that try to cast light upon the whole of Greek and Roman antiquity, including history, linguistics, numismatics, epigraphy, papyrology, history of institutions, religion, and so forth"), Lönnroth 2017 and 2020.

[4] Wolf 1807, Timpanaro 2005, and the relevant chapters in Lanza and Ugolini 2022.

of philology (an important metaphor) was vast: 'the harvest truly is plenteous, but the labourers are few'. But philology was presented as an empirical discipline. It focused on data, and had a very precise methodology for analysing them. This meant that philology was, in principle, a finite enterprise. There are a finite number of manuscripts and texts. When all the texts have been edited, all the manuscripts read and examined, the enterprise is over. In 1875, in the notes for a book he never completed, Nietzsche wrote that

Die Philologie als Wissenschaft um das Alterthum hat natürlich keine ewige Dauer, ihr Stoff ist zu erschöpfen.

Philology, as a science concerning antiquity, naturally does not last forever, and its material must run out.[5]

After a century of philological endeavours, some began to think that the field of classical philology was barren.

In 1917, the Italian scholar Romagnoli launched a strongly worded attack on German 'scientific' philology. He argued that Italian scholars had been lured into philology at a time, the end of the 19th century, when the work was already done:

quando l'Italia fu spinta nel nobile arringo della filologia scientifica, il meglio del lavoro era già compiuto. Le vigne erano state già vendemmiate, s'era fatta anche la ribrúscola. Non rimaneva che qualche acino qua e là, sfuggito agli occhi líncei delle spigolatrici. Fruga fruga, i poveri Italiani trovavano poco o nulla.

when Italy was thrust into the noble joust of scientific philology, the best work had already been done. The vineyards had already been harvested; there was nothing left to glean. All that remained were a few grapes here and there that had escaped the lynx-eyed gleaners. The poor Italians rummaged and rummaged, but found very little, or nothing.[6]

The evidence allowed only a meagre harvest. The problem was not only that the data was limited, but also that the methodology yielded uncertain results. Philologists reached different conclusions using

[5] My translation from a text by Nietzsche, written in March 1875, and published in Colli and Montinari 1967: 107 as fragment 5 [62].

[6] My translation from Romagnoli 1917b: 175 = Romagnoli 1917a: 164.

the same methodology. Different scholars offered different stemmata for the same manuscript traditions; different scholars offered different assessments of the authenticity of authorial attributions; Homeric scholars reached different conclusions about the origin of the Homeric poems.[7] The philological method was based on rules that were often applied mechanically and produced absurd, or contradictory, results. In 1922, Housman claimed that the 'scientific' method of 19th-century philology was no progress at all:

> It is supposed that there has been progress in the science of textual criticism, and the most frivolous pretender has learnt to talk superciliously about 'the old unscientific days'. The old unscientific days are everlasting, they are here and now; they are renewed perennially by the ear which takes formulas in, and the tongue which gives them out again, and the mind which meanwhile is empty of reflexion and stuffed with self-complacency. Progress there has been, but where? In superior intellects: the rabble do not share it.[8]

Here, then, the idea of methodological progress was sacrificed in favour of celebrating superior human intellects, not least Housman's own: as I argue below, philologists have often been keen to celebrate their own and their colleagues' prowess. The 'philological method' also faced criticism for its rigid rationalism, which can foster general doubt about textual transmission or even historical facts: ancient texts may be corrupted, and often report fanciful or contradictory information. One could thus argue that it is impossible to be absolutely certain of the soundness of a text. The same method could also, paradoxically, lead to universal credulity: several manuscripts attesting to the same text, several texts attesting to the same construction, several texts coherently reporting the same event could lead to the fallacious conclu-

[7] On the stemmata of manuscript traditions, see e.g., the different cases analysed in Pasquali 1934. On authenticity, see e.g., the controversy about Plato's *Seventh Letter*: Pasquali 1938: 47-154, Frede in Burnyeat et al. 2015: 6-8, for surveys of 19th-century scholarship. On Homer see e.g., West 2011: 55-8; he emphasises that "a series of scholars reached a considerable degree of accord" (58), while acknowledging that "each critic has his own analysis, and no two agree exactly in their reconstruction of the original continuum" (57); West emphasises that some conclusions were widely shared, in spite of notable differences.

[8] Housman 1922: 84 = Housman 1972: 1069. See the discussion of these problems in Battezzato 2021: 29-34.

sion that its contents ought to be accepted. The Italian philosopher and historian Benedetto Croce wrote in 1913:

Applicando invero il più rigoroso metodo delle testimonianze, non c'è testimonianza che non possa essere messa in sospetto e infirmata, e la storia filologica conduce a negare la verità di quella storia, che voleva costruire [...]. Col metodo filologico non v'ha modo di rigettare nemmeno i miracoli, riposanti sulle medesime attestazioni onde si tiene accertata una guerra o un trattato di pace.

Indeed, if we apply the most rigorous method of examining the evidence, no testimony is beyond suspicion or invalidation: philological history ultimately denies the truth of that history which it sought to construct [...]. With the philological method, there is no way of rejecting even miracles, which are based on the same attestations by which a war or a peace treaty are considered certain.[9]

Some of the attacks on the philological method were politically motivated.[10] As Terry Eagleton put it: 'Since England happened to be passing through a major war with Germany, it was possible to smear classical philology as a form of ponderous Teutonic nonsense with which no self-respecting Englishman should be caught associating.'[11] Italian and French scholars shared similar feelings.[12]

But the reasons were not only political. Other fields, such as the study of linguistics and modern literature, abandoned 'philology' as a method or a label in favour of other forms of self-identification. The Department of Comparative Philology at Harvard changed its name to the Department of Linguistics in the late 1940s.[13] Linguistics and literary analysis 'may be seen as sibling disciplines in that they were born of the same parent, philology'; so much so that one can trace the path 'from philology to English studies'.[14]

[9] My translation from Croce 2007: I, 254. The original version of the essay was published in 1913; the first Italian edition in book form was Croce 1917.

[10] Not Croce's; he published his book first in German: Croce 1915. When Croce published his book in Germany, Italy was at war with Austria, not with Germany (Italy declared war on Germany in August 1916).

[11] Eagleton 2008: 25-6.

[12] As an example of anti-German French scholarship, see Bérard 1917, attacking one of the manifestos of 19th-century philology, Wolf's 1795 *Prolegomena* to Homer (commented edition, with English translation, Wolf 1985).

[13] Watkins 1990: 24.

[14] "From philology to English studies" is the title of Momma 2012; the quotations

Critical editions, however, continued to be produced. In Italy, Romagnoli's attack on philology provoked controversy.[15] Pasquali wrote the most convincing reply in defence of philological methods of textual analysis.[16] Romagnoli essentially argued that the study of antiquity should shift from producing critical editions aimed at specialists to writing works of literary criticism aimed at the general public. He also proposed reception and translation practices that would support creative perspectives to make ancient texts more relevant to the present. Romagnoli's attempts at literary criticism were weak, but his translations had great impact,[17] as did his work in support of performance. In 1914 (three years before his anti-philological pamphlet) he had founded the National Institute of Ancient Drama (Istituto Nazionale del Dramma Antico) in Siracusa. Tasked with staging Greek and Latin dramas, it has been one of Italy's most influential cultural institutions for over one hundred years.[18] Romagnoli even wrote some plays based on classical themes himself.[19]

In his reply, published in 1920 in the form of a short book, Pasquali reiterated that many texts still needed critical editions. He accepted the assumption that the textual criticism of some authors was at an end. He admitted that there was little need for new editions of classical authors, and much need for editions of late antique ones.[20] This is a claim that can and has been disputed. Indeed, Pasquali's own later publications argued for the need to re-examine the manuscript tradition of the major classical writers, on the grounds that late manuscripts, often hastily rejected as 'contaminated' or 'copies', actually contained important

are from Momma 2012: 185; see his further references.

[15] The controversy has been much debated: see esp. Timpanaro 1963 and 1972: 298-305; Degani 1968 = Degani 2004: 937-57; Degani 1989: 1100-7, 1128-34 = Degani 2004: 1081-8, 1109-15; Degani 1999: 303-10 = Degani 2004: 1292-9; Moretti 2000: 270 and 282-3 (more in general Cavarzere and Varanini 2000); Heitmann 2005: 521-31; Baldi and Moscadi 2006; Pagnotta and Pintaudi 2015; Bossina 2016; 280-7 =Bossina 2022: 245-9; Piras 2017: 192-4; Battezzato 2023 with further references.

[16] Pasquali 1920; see the reprint Pasquali 1964.

[17] See e.g., Romagnoli 1924.

[18] On the history of this festival, see esp. Berezin 1994: 1255 and 1270-1 (Fascist support for the festival).

[19] See e.g., Mulè and Romagnoli 1928 (Mulè wrote the music for the play); Romagnoli 1928.

[20] See Pasquali 1920: 14-5 = Pasquali 1964: 19.

textual information that was otherwise unavailable.[21] This insight led to a series of new editions of Greek tragedy, Aristophanes, and Plato, for instance.[22] In 1920, however, Pasquali conceded to the anti-philologists that classical texts did not need new critical editions and that textual critics should focus on the large body of poorly edited late antique texts by, e.g., Basil, Gregory of Nyssa, Gregory of Nazianzus, Libanius, Themistius, and Himerius.[23] Coincidentally, Pasquali had just prepared an edition of the letters of Gregory of Nyssa, which was subsequently published in 1925.[24]

At the same time, Pasquali disagreed with Romagnoli on the issue of translation. He argued that not all ancient texts should be translated. Pasquali offered a strongly hierarchical conception of the canon: some texts were truly 'classical', while others were simply 'ancient'. He refused to give a list of 'classical' authors, claiming that the canon would change over time, but he strongly implied that some authors, such as Homer, would always be considered classical.[25] Classical authors are read for their artistry, he argued; 'ancient' authors for the information they provide. One should not translate 'ancient' authors: classicists should be able to read them in the original and extract the information they contain. Exceptions could be made for texts of interest to non-classicists, or for texts presenting particular interpretive difficulties.[26] This stance had paradoxical consequences: modern philologists were left with the task of publishing critical editions of 'ancient' authors, not of 'classical' ones. The 'classical' authors had already been properly edited, Pasquali thought in 1920. If this is so, what is the point of philological training? The point is to enable scholars to read texts in the original. His arguments against translation were, needless to say, a gate-keeping gesture. Only those who had undergone the long and complicated training of a philologist were to be allowed near the ancient texts. All others could catch a glimpse of the brilliance of Virgil or Homer through some pale modern imitations. This attitude has not

[21] Pasquali 1934.

[22] See e.g., Dawe 1964, Dawe 1973, Di Benedetto 1965, Mastronarde and Bremer 1982, Diggle 1991, on the the manuscript tradition of tragic authors; Dover 1968 for Aristophanes; Dodds 1959 and Boter 1989 for Plato.

[23] Pasquali 1920: 14-5 = Pasquali 1964: 19.

[24] Pasquali 1925.

[25] Pasquali 1920: 30 = Pasquali 1964: 34.

[26] Pasquali 1920: 30-2 = Pasquali 1964: 34-6.

entirely disappeared. Pasquali explicitly condemned 'easy democratic science', alluding (paradoxically) to Romagnoli (who was soon to prove himself an ardent Fascist).[27] It is easy to criticise Pasquali (or Romagnoli, for that matter) with the benefit of hindsight – at least in terms of assessing their politics – but examining their disagreement reveals much about their attitudes to philological practice.

Textual criticism and translation, contrary to what Romagnoli and Pasquali each argued, are not dead or useless. Pasquali himself later demonstrated the need for a new approach to textual criticism. It should be added that there is no such thing as a 'definitive edition' of a text, especially of an ancient classical text. The evaluation of the manuscript evidence is only part of the equation, as the study of language and metre continues to evolve and improve. More importantly, and contrary to the positivist rhetoric of the 19th century, it should be acknowledged that an element of subjectivity is inextricably linked to textual choices.[28] Philology cannot always work with 'hard' facts. Some linguistic or metrical structures are undoubtedly impossible in certain texts and eras, but language is inherently flexible, and every author, ancient or modern, makes creative use of it. For this reason, even when the text transmitted by the manuscripts is clearly incorrect – for example, because it is unmetrical or nonsensical – we often have to accept a degree of uncertainty in reconstructing the correct version. The same applies to manuscript traditions: it is often impossible to reach a firm conclusion about textual relations, even when the reconstruction of a stemma seems possible.[29] The positivist rhetoric of factual certainty damaged the philological enterprise by claiming certainty even when the data did not allow it. Philologists preferred to base their authority on strong statements, not always backed by facts, rather than admit uncertainty or, worse still, subjectivity.

The rejection of any suggestion of subjectivity also led scholars to underestimate the importance of translation. Translation was used in pedagogical practices, or as a 'creative' enterprise that had little to do

[27] Pasquali 1920: 32 = Pasquali 1964: 36: "comoda scienza democratica".

[28] See e.g., Tarrant 2016: 29 and esp. 40 ("No edition of a classical text can be definitive").

[29] Compare, for example, the different views of the stemma for Pindar expressed by Turyn 1932, Maas 1933, Irigoin 1952, and Snell 1959. Maas offers a compelling refutation of Turyn's stemma, but his reconstruction (essentially followed by Snell), and that of Irigoin are both possible.

with philology. Pasquali never recanted his statements about translation. His insistence that ancient texts should not be translated implied that true classicists read only in the original. This is in fact reflected in the common practice of critical editions: Teubner and OCT (unlike the Budé series) do not offer translations. Teubner was the flagship series of critical editions in the 19th century. This practice implies that there is only one possible translation for each text, and that this translation is obvious. Pasquali endorsed translations only for texts that were 'difficult to interpret', suggesting that for the most part translation was uncontroversial.[30] It is a common experience, however, that translating a text often forces one to rethink and sometimes to doubt the correctness of the transmitted text. Finding a problem is the starting point for proposing a solution.[31] The rhetoric of certainty, both in the philological practice of preparing critical editions and in the practice of reading ancient texts, downplays uncertainty. This is also apparent in the rhetoric of scholars who offer conjectures.

2. *Conjectures: Divine, Human, and Computational*

The philologist needs to 'feel' the classical text: Romagnoli proclaimed this subjective and intuitional necessity. Pasquali rejected 'feeling' as arbitrary. Yet, in fact, Wilamowitz, Pasquali's ideal philologist, explicitly affirmed the need to 'feel' the classics.[32] Wilamowitz insisted on 'feeling' based on a hermeneutic theory with a specific and explicit religious justification: the 'daemon' of the (exceptionally perceptive) philologist could establish some sort of connection with the ancient author and, as it were, bring that author back to life – through conjecture. Conjecture was therefore conceived as an attempt to reach into the mind, or even the 'soul', of an ancient writer. Wilamowitz often attributed a daemon to exceptionally gifted people. As Plutarch argued, 'the thoughts of daemons are luminous and shed their light on the daemonic man' (589b); 'the messages of daemons pass through all other men, but find an echo in those only whose character is untroubled and soul unruffled, the very men in fact we call holy and daemonic' (589d).[33] If, as Wila-

[30] Pasquali 1920: 31 = Pasquali 1964: 35 "d'interpretazione difficile".

[31] See Nisbet 1991 = Nisbet 1995: 338-61; Conte 2013; Battezzato 2019.

[32] On 'feeling' and the classics, see Güthenke 2020.

[33] Translation from Einarson and De Lacy 1959.

mowitz believed, philology consists of a process of *Einfühlung*, that is of 'feeling' oneself into another person, then the philologist is a 'holy and daemonic' individual who can be in contact with what other human beings once thought and wrote.[34] Conjecture is a way of making contact with the souls of people who died millennia ago. This mystical view of conjecture is, in fact, in line with ancient theories of philology. Athenaeus (XIV 634d) reports a saying about Aristarchus: 'the philosopher Panaetius of Rhodes used to refer to him [Aristarchus] as a 'mantis' ("seer"), because he could easily divine the point of a poem'.[35] In the 18th century, Bentley took up this claim and argued that the philologist needed to be endowed, 'as they used to say of Aristarchus, with a certain ability in divination and with the gift of prophecy'.[36] The concept of divination travelled from antiquity to Bentley and was used in the 19th- and 20th-century German tradition. Kurtz observed that 'hermeneutics, too, involved divination, which involved a fallible and corrigible process of hypothesis to press beyond the limitations of empirical evidence into the contingent world that conditioned a work'; and he noted that 'towards the fin de siècle, divination suggested a psychological self-projection of the interpreter on the interpreted'.[37]

Another common set of philological metaphors relates to victory: a conjecture may be called 'palmaris' (or 'palmaria'), i.e. worthy of the palm of victory[38] (a symbol adapted in the Christian tradition to celebrate the 'victory' of martyrs). The term highlights the competitive na-

[34] On this, see Battezzato 2023.

[35] Translation from Olson 2011. The passage is fr. 93 in Straaten 1962. On this passage, see Porter 1992: 70 (who argues for an ironic interpretation of the passage), Seppänen and Lampinen 2019: 901-2. The statement may contain exaggerated praise, but it is not presented as ironical in the context of Athenaeus.

[36] See Bentley 1711 c: "ut de Aristarcho olim praedicabatur, divinandi quaedam peritia & μαντικῆι". On this statement, see Scognamiglio 2021. On the links between philology and divination in antiquity, see Seppänen and Lampinen 2019. Note that Cicero, *On Divination* 2.74, in a discussion about Roman seers, contrasted *coniectura* (an inference made on the basis of elements perceived by the senses) with *diuinatio* (divinely inspired knowledge of events that could not have been known otherwise). On divination in modern philological theory, see Kurtz 2021: 761 and n. 39, with further references.

[37] Kurtz 2021: 761 and n. 39.

[38] See e.g., Carrion 1576: 26 "scribendum conicio, quae mihi coniectura paene palmaria est, de veteris scripturae vestigijs", Carrion 1579: 218 "emendatio palmaria",

ture of the philological enterprise: philologists must be celebrated for defeating errors in the manuscript tradition, or for proving their superiority over rival philologists. The metaphor stresses the effort required to achieve victory: 'sacrifices' (another religious metaphor) must be made to secure 'victory'. Similar language is used in sport and religion. Paradoxically, modern editors of sacred texts are wary of proposing and accepting conjectures: these texts are so foundational to Western culture, and their authority so strong, that the idea of changing them by 'conjecture' is rarely countenanced.[39] Philologists, it seems, can hope for a mystical connection with ancient authors only if these authors did not write canonical religious texts – presumably, the assumption here is that God took care to prevent textual corruption in divine texts.

The first instantiations of what would become the modern apparatus criticus appeared in the 16th century; scholars used sigla to designate manuscripts in their collations.[40] A crucial feature of the modern apparatus criticus, however, is that it lists the names of the authors of conjectures. This has the practical aim of helping other scholars to find the arguments that philologists sometimes (though not always) used to support their suggestions. It also gives the reader a sense of the progress made over time in establishing the text; those in the know, when reading the name of a philologist, can place him (or, more rarely, her) in time, which in turn helps to assess the conjecture. Renaissance conjectures often dealt with basic problems of syntax or morphology, whereas later conjectures, especially from the 19th and 20th centuries, are often based on more advanced knowledge of metre, language, and style.[41] However, the naming of philologists in the apparatus is not only

Modius 1584: 101 and 387 "palmaria correctio", "palmaria emendatio", Brink 1978: 1149, Brink 1986: 71.

[39] See Cohen 2023: 4, 45-6, 50, 56, 89, 126, 172 on the reluctance to emend sacred texts (e.g., 172: "there is a growing reluctance to emend without compelling reason", in practice only when we find "obvious scribal errors"); this, for instance, rules out the possibility of deleting obvious interpolations, such as the end of the Gospel of Mark, or the episode of the adulterous woman in the Gospel of John: see, in general, Ehrman 2005, Battezzato 2009.

[40] Sigla used in Renaissance collations: Battezzato 2006, Reeve 2006: 179-80 (criticising Flores and Tomasco 2002). Timpanaro 2005: 65 lists Bengel 1763 as the first occurrence of the term *apparatus criticus*.

[41] Some scholars give the precise bibliographical reference for each emendation, which again helps the reader: see especially West 1990b.

the result of practical considerations – it is also a way to immortalise their names. The 'great souls' of modern philologists who were able to 'feel' what the ancient author wrote will not perish. Their 'victory' over (textual) corruption and (scholarly) rivalry will be celebrated in perpetuity. Mentioning the name of the philologist who first advanced a conjecture (or a supplement) is thus considered not only good scholarly practice, but also a way of honouring their work. Editions that do not mention the name of the author of a conjecture do exist, but they aim to simplify the task of reading an apparatus for a student audience.[42]

As many scholars have observed, conjectures are based on 'feeling' and intuition, more than, or in addition to, knowledge of language, metre, and style. As Housman puts it: "Textual criticism is a science, and, since it comprises recension and emendation, it is also an art".[43] If so, emendation involves a creative element, not a scientific one. This in fact leads to 'open' editions. Some conjectures (the truly 'palmary' ones) are generally considered 'correct'. However, on several issues, each philologist will 'feel' differently – both about the need for a conjecture and in choosing the right one.[44]

'Feeling' what the ancient text must have been like and 'studying' language, metre, and style actually correspond to two fundamental modes of human thinking. Kahneman called intuition 'System 1', a mode of thinking which 'operates automatically and quickly, with little or no effort and no sense of voluntary action'.[45] This applies to everyday life, as well as to intellectual endeavours such as reading. People are able to 'read' words or parts of words that are missing from a text; they read the right word instead of a misprint. But intuition is only part of the picture. Scholars must resort to analytical judgement; they must test hypotheses and check dictionaries, grammatical works, and statistical evidence about word usage.[46] This kind of work is always necessary to confirm a conjecture based on 'intuition'; it may also be the basis

[42] Some editions in the *Cambridge Greek and Latin Classics* series (often known as the "Green and Yellow" commentaries) use a generic siglum, such as *c*, to indicate a conjecture, omitting the name of the scholar who devised it: see e.g., Denyer 2001, Gray 2007.

[43] Housman 1922: 68 = Housman 1972: 1058.

[44] See Trovato 2017: 243-74.

[45] See Kahneman 2011: 20; Kahneman and Tversky 2000; Gilovich et al. 2002. For a more detailed discussion of the psychology of conjecture, see Battezzato 2019.

[46] See for instance Diggle 1994.

from which a textual conjecture emerges. Analytical work corresponds to what Kahneman calls 'System 2', which 'allocates attention to the effortful mental activities that require it, including complex computation'; its operations 'are often associated with the subjective experience of agency, choice, and concentration'.[47]

In fact, both systems are present and intertwined in any scholarly activity.[48] Skilled readers use intuition ('System 1') more often: in "an environment that is sufficiently regular to be predictable"[49] intuition leads to reliable (though not flawless) predictions. As Kahneman points out, "as you become skilled in a task, its demand for energy diminishes", and "the pattern of activity associated with an action changes as skill increases, with fewer brain regions involved".[50] However, people working on ancient texts must constantly revert to 'System 2'. Non-native speakers of a language often fail to notice mistakes that native speakers would easily spot. Scholars who read texts in ancient languages are not native speakers. When they edit a text, they must make sure that it conforms to the linguistic and stylistic norms expected of that particular author or period. This practice is even regularly theorised in textual criticism handbooks and is referred to as the need to check the *usus scribendi* of each author.[51] One way of putting this is to say that 'System 2' must be used to examine every element of the ancient text. If the transmitted text appears to be incorrect, scholars can use 'System 1' and/or 'System 2' to look for new solutions to problems that were not noticed on the first (or second, or third) reading.

The 'art' of conjecture corresponds to 'System 1'; the 'science' corresponds to 'System 2'. The main question addressed in this volume

[47] Kahneman 2011: 21. We are not concerned here with the question of whether all of Kahneman's research results could be replicated. Some have been contested (see Schimmack 2017 and 2020) as part of the so-called replication crisis (see e.g., on psychology, Maxwell, Lau, and Howard 2015; Forbes, Travers, and Johnson 2023; on the implications of the replication crisis for the humanities, see Kramnik 2023: 89); indeed, Kahneman's own research has discussed the problem of replicability, and discussed it in relation to his own work: Kahneman 2017. These specific details do not affect the general concepts used by Kahneman.

[48] The following paragraph reformulates what I wrote in Battezzato 2019: 13.

[49] Kahneman 2011: 240.

[50] Kahneman 2011: 35. See 451 for references.

[51] See e.g., Pasquali 1952: 122-4; Maas 1958: 10-3, 41; West 1973: 56-9; Timpanaro 2005: 68-9, 88, 124, 137; Battezzato 2009: 775.

is what happens when we add Artificial Intelligence to the human and divine ways of understanding the restoration of ancient texts: does AI use 'System 1' or 'System 2', or a combination of both? Logion is based on a statistical model: it introduces what is statistically expected to be found in a text. In doing so, it brings to the fore an essential contradiction in philology: on the one hand, it aims to standardise the text, to make it more predictable and banal. This is what scribes (and readers) do unconsciously ('System 1'). Philologists have long established that when two readings are transmitted, the 'more difficult' one (*lectio difficilior*) is to be preferred.[52] On the other hand, philologists, by looking at an author's *usus scribendi*, claim that the text that is more likely to be correct (another probabilistic judgement, this time made by human beings) is the less unusual one. These two principles are in tension with each other.[53] The 'conjectures' made by Logion reveal this tension and confront scholars with the need to rethink some of their assumptions.

Logion is unsettling also in another respect. An AI 'conjecture' is deeply subversive of the immortalising language of classical philology briefly outlined here. As many of the essays in this volume show, the AI tool Logion is capable of suggesting readings that are likely to reconstruct what the author originally wrote, even in passages that were never suspected of corruption. The number of persuasive suggestions is a fraction of the total number of suggestions. In fact, this is what also happens with human scholars: even in the case of scholars with excellent philological reputations, such as Hermann, Wilamowitz, or West, only a fraction of their conjectures is convincing.[54] Many of Logion's 'conjectures' are clearly wrong, sometimes for elementary grammatical reasons. That said, let us examine the case of a convincing 'conjecture' by Logion. What should we print in the apparatus? 'Computator'? 'Post computatorem Barnes et Sandri'? 'Computatorem secutae May et Ozbek'? Should we immortalise the AI tool? Does it make sense to speak of 'immortalising' AI? Is AI a 'daemonic' being? Can we bestow the 'crown' of victory on a soulless entity? The idea of giving AI a place of prominence in what used to be exclusive province of human beings is unsettling to many scholars – despite the fact that we humans have

[52] See e.g., Pasquali 1952: 122-6; Maas 1958: 13; West 1973: 51; Battezzato 2009: 775; Trovato 2017: 117-24, and Graziosi, chapter 1 in this volume: 19 and n. 17.

[53] See e.g., Pasquali 1952: 12, 122-6; Battezzato 2009: 775.

[54] See e.g., West 1990a: 355-72, along with the remarks in Di Benedetto 1992: 152-3 = Di Benedetto 2007: 1230-31.

been using electronic tools to work on philological problems for decades now. The first planning meeting that eventually led to the creation of the *Thesaurus Linguae Graecae* took place in 1972. However, it is one thing to use a tool that simply provides access to data; it is quite another to have a tool like Logion that suggests its own candidates for likely textual corruption and can create new data, for instance by supplementing lacunae. This is all the more disturbing given that we do not really have access to Logion's 'reasoning'. We do not know whether Logion bases its suggestions on 'System 1' or 'System 2'; indeed, more fundamentally, we do not know to what degree or in what possible ways deep neural networks like Logion resemble human reasoning.[55]

What is essential to note at this point in the development of AI tools for philological tasks is that such tools do not substitute philologists. Philologists still need to evaluate Logion's suggestions; the 'System 2' task is up to human beings. It is human beings who need to find arguments and textual parallels to support – or challenge – Logion's suggestions. In a sense, Logion's suggestions are not actually 'conjectures': Logion makes different suggestions for the same passage based on the limits set by its human users. The suggestions may differ by one, two, or more letters from the text under consideration: the greater the distance from the text, the slimmer the chance of producing a convincing suggestion.[56] This shows how much Logion is controlled by humans. Human philologists can decide on the extent of an intervention in the text (from a punctuation mark or word division, which is distance 0, to a complete rewriting of a word, e.g., by transposing syllables). Not only that: it takes a human being (or more than one) to decide what is worth discussing, and accepting, and what is not. Finally, it takes a human being (or more than one) to produce an edition, to decide what combination of readings is acceptable in the thousands of words that make up the text.

Another issue worth highlighting here is that of translation. Classical scholarship has often focused on a narrow canon of texts. After all, this is what 'classical' means, not least in its relation to social class.[57] One

[55] For a basic introduction to how Logion is trained, see Brooks and Cowen-Breen, chapter 4 in this volume.

[56] See the essay by Barnes and Sandri, chapter 6 in this volume.

[57] See Aulus Gellius, *Attic Nights*, 19.8.15 "So go now and inquire, when you chance to have leisure, whether any orator or poet, provided he be of that earlier band – that is to say, any classical or authoritative writer, not one of the common herd [*id est classicus adsiduusque aliquis scriptor, non proletarius*] – has used *quadriga* or *harenae*"

upshot of establishing a classical canon is that ancient texts not considered worthy of the term have neither been translated nor properly edited. This is particularly problematic for Greek texts when it comes to late-antique and Byzantine literature. These texts are often dense and complex – and extremely lengthy. Many AI tools offer help with translations, even if Logion has not yet been adapted for this task. Translations often reveal the presence of textual problems: humans often translate what should be in the text but is not. Translations would also help to attract readers by making texts accessible to a wider audience. But even if an AI tool could translate such texts in full and make them intelligible to modern readers, there would still be a need for experts: translation tools can certainly make mistakes and need human supervision and assessment.

Dario Amodei recently wrote:

> I think it is very likely a mistake to believe that tasks you undertake are meaningless simply because an AI could do them better. Most people are not the best in the world at anything, and it doesn't seem to bother them particularly much. [...] people [...] greatly enjoy activities that produce no economic value. [...] In any case I think meaning comes mostly from human relationships and connection, not from economic labor. [58]

So, what is the point of all this work? It only makes sense to invest in editions and translations if people read them. The hope is that AI tools like Logion will make it easier for new readers to access ancient texts. These texts were created for the pleasure, education, and (alas) frustration of human beings. Without readers, philology is meaningless. But without editions, there are no readers. And without readers, there is no meaning.

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(translation Rolfe 1927). On the relationship between classics and class, see e.g., Hall and Stead 2020: 25-6.

[58] Amodei 2024.

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3. What is Artificial Intelligence Good For? A Philological Perspective

This chapter argues that language models like Logion can answer pressing needs in current philological scholarship. Focusing on the problem of human bias, it argues that machine-generated suggestions can challenge preconceptions that get in the way of successful philological work. This claim is illustrated via three case studies of progressively greater philological complexity and significance, from a simple case of textual corruption to more complex issues of adjudication between manuscript readings, all the way to questions of authorial attribution.

Keywords: Authorial Attribution; Expertise (in Philology); George Pachymeres; Human Bias; Word Division; Ancient Greek; Premodern Greek

Technological innovation tends to outpace practical applications, as countless examples make clear. The combustion engine, to mention just one, was invented before it became at all clear how it could best be put to work. Our human response, in the face of innovation, is often to blame new technologies for being useless – by saying, for example, that they take time to mature. That is true, to be sure, but it takes a human investment of time and ingenuity to see how emerging technologies may answer our needs. Incidentally, this is not just a matter of inventing new needs: there was demand for efficient locomotion long before combustion engines were invented, even if those engines then drove forward desires and needs. We are now facing a formidable challenge in our human response to artificial intelligence. Logion, the deep neural network we created for the purpose of assisting philologists working on premodern Greek texts, is a specific example of that general impulse to investigate how new technologies can be put to work. The second half of this volume explores Logion in some detail, first introducing readers to how it was trained (Brooks and Cowen-Breen), then

Haubold, J. 2025. "What is Artificial Intelligence Good For? A Philological Perspective" in Battezzato, L., Graziosi, B., and Haubold, J. eds. *Artificial Intelligence and Greek Philology: An Experiment*, Pisa: 59-93.

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asking how it performs in relation to a typology of outcomes (Li and Haubold), across different settings (Barnes and Sandri), and compared with human philologists (May and Ozbek).

In this chapter, I begin not with an assessment of Logion, the new technology under development, but with an understanding of what human needs it currently helps to address. As Battezzato discusses in his contribution to this volume, Greek philology has long aspired to the status of an objective science while simultaneously engaging in partisan polemic fueled by personal pride and a quest for fame. In view of that tension, he points out that textual critics express legitimate and unavoidably subjective responses in their work.[1] Today the vanities of 19th-century scholarship are mercifully a thing of the past, yet the challenges of subjectivity in the restoration of premodern texts continue, for the simple reason that editions seek to preserve and elucidate those texts rather than rewrite them according to the personal preference of the person or people making the edition. My brief here is not to explore the issue of subjectivity at an abstract theoretical level, but to consider some practical ways in which AI can help move the field forward in relation to that question.[2]

To be clear, my point is not that machines are free from bias, far from it, as amply illustrated also in this volume. Rather, my point is that machine bias, under certain conditions, differs markedly from human bias – and that is a fact that can help philologists see new possibilities and become more aware of their own preconceptions.

1.

My first example of how Artificial Intelligence can help comes from a short treatise on virtue by Michael Psellos. The relevant passage reads as follows (Psell. *Phil. min.* II 32: 110.17-25 O'Meara):

καὶ ἡ μὲν περίγειος τετρακτὺς αὕτη τῶν ἀρετῶν, ἡ δὲ ἀνάλογος ἐν τρίταις καὶ τετάρταις ἐστίν, ὅταν τις ταύτας καὶ ἐν τῇ τρίτῃ τάξει θεωροίη τῶν νοερῶν ἀρετῶν καὶ ἐν τῇ τετάρτῃ τῶν παραδειγματικῶν, εἴποι **μοι** δ' ἂν αὐτὸς καὶ ἐν τῇ δευτέρᾳ τῶν θεωρητικῶν. τότε γὰρ ἡ τετρακτὺς τῶν τεττάρων γενικῶν

[1] Above, chapter 2 in this volume: 44-5.

[2] More general reflection in Graziosi and Battezzato, chapters 1 and 2 in this volume, with further literature.

ἀρετῶν ἐν ταῖς τρίταις καὶ τετάρταις τάξεσι τοῦ νοεροῦ βαθμοῦ καὶ τοῦ παραδειγματικοῦ κατὰ ἀναλογίαν ἐμφαίνονται.

So, this is (what he means by) the 'earthbound' set of four virtues. The 'analogous one in the third and fourth' is when one considers the virtues also on the third level where they are intellective and on the fourth where they are paradigmatic – and he(?) himself(?) would also say to me(?), on the second level where they are contemplatives. For that is when the four principal virtues become apparent by analogy also on the third level of the intellective and the fourth level of the paradigmatic.

In this case, Logion, the deep neural network showcased in this collection, flags μοι as suspect and suggests -μι instead. Let me take a moment to untangle the passage. As Psellos himself explains earlier in the same text, he is helping a friend understand a letter by the bishop and philosopher Synesius (Psell. *Phil. min.* II 32: 109.7-10 O'Meara):

τὴν πρὸς Ἑρκουλιανὸν ἀνεγνωκὼς ἐπιστολὴν Συνεσίου ἐπιζητεῖς τί ποτέ ἐστι τὸ ἐν ταύτῃ κείμενον ῥησίδιον τὸ βούλεσθαι αὐτὸν 'μεταθεῖναι τὴν τοῦ σώματος ἰσχὺν ἐπὶ τὴν τῆς ψυχῆς ἀνδρείαν, οὐ τὴν ἐκ τῆς πρώτης καὶ περιγείου τετρακτύος τῶν ἀρετῶν.'

Having read Synesius' letter to Herculianus you wonder what he means by saying that he wants him[3] to 'transfer the strength of the body to the courage of the soul, (but) not to that courage which belongs to the first and earthbound set of four virtues.'

Synesius writes about the four cardinal virtues – courage (ἀνδρεία), temperance (σωφροσύνη), prudence (φρόνησις) and justice (δικαιοσύνη). He sees them as operating on four different planes: that of 'earthly' or political matters; that of contemplation, which Psellos also calls 'cathartic'; that of the intellect; and that of Platonic ideas. Here is how Synesius had summarized the system in his letter (*Ep.* 140.30-38 Garzya):

γένοιτο δ' ἂν οὐ μάτην εἰ πρῶτον μὲν ἐπιδοθείη, τὸ δὲ ἐπὶ τούτῳ καὶ τούτου σεμνότερον, <εἰ> κατανουθετήσει σε καὶ παιδαγωγήσει καὶ πείσει μεταθεῖναι

[3] The syntax is ambiguous, but comparison with Psellos' source confirms that αὐτόν refers to the addressee, not the sender, of the letter; cf. Synesius *Ep.* 140.33 Garzya (σε).

τὴν τοῦ σώματος ἰσχὺν ἐπὶ τὴν τῆς ψυχῆς ἀνδρείαν, οὐ τὴν ἐκ τῆς πρώτης καὶ περιγείου τετρακτύος τῶν ἀρετῶν, ἀλλ᾽ ἐπὶ τὴν ἀνάλογον ἐν τρίταις τε καὶ τετάρταις. ἄψαιο δ᾽ ἂν αὐτῆς ὅταν μηδὲν τῶν ἀνθρωπίνων θαυμάζῃς.

I suppose it [= this letter] won't be in vain if it is delivered in the first place; and after that, and more importantly, if it instructs and educates you and persuades you to transfer the strength of your body to the courage of your soul – not to that courage which belongs to the first and earthbound set of four virtues but to the analogous virtue among the third and fourth. You may attain it if you admire nothing in human affairs.

In good Platonic fashion,[4] Synesius steers his addressee away from the sphere of the body to that of the mind. In order to do so, he points to a correspondence between a first, earthbound, set of virtues and higher virtues belonging to more elevated planes. He mentions a third and fourth plane but skips over the second. Psellos fills in the gap, clearly marking the addition.[5]

Now, the transmitted text would have Psellos say εἴποι μοι δ᾽ ἂν αὐτὸς κτλ, which is syntactically unusual since we would not expect the particle δέ in this position in the sentence.[6] Moreover, the statement seems strange also at the level of content: why would Synesius 'himself' (αὐτός) fill the gap in his own argument? It is rather Psellos who supplies the missing second set of virtues, using a favorite expression of his to mark the addition: a proximity search of the TLG confirms that Psellos was fond of using this type of expression.[7] He does

[4] For Synesius' brand of Platonism see Tanaseanu-Döbler 2008, with further literature.

[5] Monticini 2024: 835-6, n. 374, refers to Plotinus I.2 (19) and Porphyry, *Sentences* 32: Porphyry discusses the second order of virtues (theoretical). For the hierarchy of virtues more generally, see Saffrey and Segonds 2001: LXIX-XCVIII. For the text of Psellos which summarizes Porphyry, *Sentences* 32, see LXXXVIII-LXXXIX, n. 2.

[6] I am grateful to Luigi Battezzato for pointing this out. TLG lists only a handful of apparent exceptions, which require further investigation: Psell. *Log.* 7.97 (ὅρα μοι δὲ ...), *Psych.* 112.15 (οὔ μοι δὲ δοκοῦσι), *Enc. matr.* 1551 (δίδου μοι δὲ ...), *Ep.* 389.22 (ἔσο μοι δὲ εἰδὼς ὅτι ...). The expected collocation (heavy punctuation + word +) δέ μοι runs to almost 250 attestations in the works of Psellos as currently available in the TLG.

[7] Much depends on how one sets the search parameters and counts the results. Psellos uses εἴποιμι with αὐτός eight times. Casting a wider net, he is extremely fond of asking himself πῶς ἂν εἴποιμι, 'how shall I put it?' (30+ times).

this to paraphrase a text,[8] or to claim an unusual formulation as his own.[9] More relevant for the purposes of the present argument, Psellos uses this type of expression also in philosophical contexts, to advertise his own opinions and contrast them with those of other thinkers. The following passage may serve as an example (*Theol.* I 72.68-79 Gautier):

εἰ γὰρ καὶ πανταχοῦ λέγεται εἶναι ἀλλὰ καὶ ὑπὲρ τὸ πᾶν αὐτὸν τὰ θεῖα τιθέασι λόγια· καὶ πανταχοῦ μέν ἐστιν, ὅτι πάντα ἐκείνου μετέχει, διότι καὶ ἐκεῖθεν παρῆκται, ὑπὲρ τὸ πᾶν δέ, ὅτι πάσῃ γενητῇ φύσει ἀπερίληπτος ὁ θεός. ἔστιν οὖν καὶ ἐν φυτοῖς καὶ ἐν λίθοις καὶ ἐν ἀλόγοις ζωαῖς καὶ ἐν εἰδωλικαῖς φύσεσι καὶ ἐν ψυχαῖς, ἔν τε νοήσεσι καὶ ἑνώσεσι καὶ ἑνάσιν· ἀλλ' ὅπου μὲν φυτικῶς, ὅπου δὲ σπερματικῶς, κἀνταῦθα μὲν ψυχικῶς, ἀλλαχοῦ δὲ νοερῶς, ἐν δὲ τοῖς ἐπέκεινα ἀνεννοήτως τε καὶ ὑπερουσίως. ὅσα μὲν γὰρ ἁπλῶς εἰσι, κατ' αὐτὸ τὸ εἶναι μετέχει θεοῦ, ὅσα δὲ καὶ ζῇ, κατ' ἄμφω, ὅσα δὲ καὶ νοεῖ, ἐπὶ μᾶλλον. εἴποιμι δ' ἂν αὐτὸς μηδὲ τὰς στερήσεις ἀμοίρους εἶναι θεοῦ, καὶ τούτων γὰρ ὑποστάτης θεός, ὅτι καὶ πάντων, ἵνα μὴ ὑπεκδράμῃ τὸν νοῦν· ὁ γὰρ νοῦς εἰδῶν ποιητής, ἀλλ' οὐ στερήσεων.

Even though God is said to be everywhere, the divine scriptures also place him above the totality of things. He is everywhere, because all things partake in him, for they are derived from there, but He is also above the totality because no generated nature can grasp God. So, He is in plants and stones and irrational animals and imaginary natures and in souls, thoughts, unions, and units. But in some things He dwells vegetatively, in others generatively, here in ensouled fashion, there in the manner of thought. In the beyond, He exists outside thought and above substance. For whatever simply exists partakes in God by the simple fact of existing. What also lives partakes on both grounds (i.e. existing and living). What also thinks, even more. And I for my part would say that not even the privations are cut off from God for God is their creator too, as He is the creator of all things, lest He become subordinate to the mind: for the mind creates the forms but not the privations.

Psellos begins by tracing the contours of a standard Neoplatonic argument: God is above all things though they simultaneously partake in him. But then he strikes out on his own, pivoting from Proclus'

[8] E.g., Psell. *Theol.* I 92.74-76 Gautier ἵν' ἄλλον τρόπον <u>αὐτὸς εἴποιμι</u> παρ' ὃν ᾐνίξατο ὁ ἐν τῷ Ἰὼβ λόγος.

[9] Psell. *Hist brev.* 105.93-96 Aerts καὶ ἐν τῷ τῶν Ἀποστόλων νεῴ, <u>αὐτὸς ἂν εἴποιμι</u>, θησαυρίζουσι [sc. τὸ σῶμα].

point that mind cannot be the source of privation.[10] The philosophical intricacies of this argument would be worth exploring further, but what matters here is its philological significance: Psellos uses εἴποιμι δ' ἄν αὐτός in precisely the kind of context that Logion flagged in the passage with which I began this discussion. The phrase does not just restore δέ to its expected position in the sentence but also chimes with what Psellos had to say about Synesius' theory of the virtues and more generally with his style of philosophical argument.

We have thus assembled three reasons to believe that Logion's εἴποιμι δ' ἄν αὐτός is indeed what Psellos wrote in *Phil. min.* II 32: 110.17-25 O'Meara. But how did the error arise, and why was it allowed to persist? Careless duplication of οι (pronounced /i/) will no doubt have played a part. A look at the only extant manuscript, MS **O** (Oxford, Bodleian Library, Barocci 131), illustrates how easy it is for such an error to be introduced (f. 412v):[11]

Fig. 1. Psellos *Phil. min.* II 32: 110.17-25 O'Meara – Oxford, Bodleian Library, Barocci 131, f. 412v. Image courtesy of Digital Bodleian.

[10] Cf. Procl. *Inst. theol.* 57: 56.16 Dodds νοῦς δὲ στερήσεως ὑποστάτης οὐκ ἔστιν, εἶδος ὤν. Elsewhere, Proclus ventures an equivocation that may have inspired Psellos to go further (*In Plat. Parm.* V 1037.7-9 Steel : τί γάρ ἐστιν, ὃ μὴ μετέχει τοῦ ἑνός; κἂν αὐτὴν εἴπῃς τὴν στέρησιν, εὑρήσεις τοῦ ἑνὸς ἴνδαλμα φέρουσαν. To this, Simplicius adds the idea that privation does have some form of *hypostasis*: see *In Phys.* 238.14-16 Diels καὶ δῆλον ὅτι κἂν καθ' αὑτὸ λέγηται μὴ ὂν ἡ στέρησις, ἀλλ' ἔχει τὴν ὁποιανοῦν ὑπόστασιν. Contrast Plot. *Enn.* I 8 (51), 11.2 στέρησις δὲ ἀεὶ ἐν ἄλλῳ καὶ ἐπ' αὐτῆς οὐχ ὑπόστασις; Joannes Scholasticus *Prol. et schol. in Dionys. Areop. Div. nom.* ch. 4 DN 175,6 ll. 1-2 ἡ στέρησις οὐκ ἔστιν ὑπόστασίς τις ἀλλὰ περὶ τὸ ἐστερημένον τοῦ παρεῖναι πεφυκότος καὶ ἐπιβάλλοντος εἴδους γίνεται. Somewhere in the background lurks the longstanding debate about the nature of evil. For evil as privation in Proclus see Phillips 2007: 57-92; also Chlup 2009. For a Christian restatement see Dionysius Areopagita, with Joseph 2015; also Schäfer 2006, Perl 2007, Wear and Dillon 2007. For god being 'above mind' (ὑπέρνους) see Proclus, *Inst. theol.* 115: 100.28 πᾶς θεὸς ὑπερούσιός ἐστι καὶ ὑπέρζωος καὶ ὑπέρνους; cf. Nic. Meth. *Refutatio institutionis theologicae Procli* 57.12-13, with specific reference to the privations: πρῶτος καὶ μόνος καὶ ὑπέρνοος καὶ ὑπερούσιος καὶ παναίτιος θεός, ὃς καὶ τὸ ἓν καὶ τὸ ἀγαθὸν παρ' ἡμῶν ὑμνεῖται, ὃς καὶ στερήσεων καὶ ἁπλῶς τοῦ μὴ ὄντος ὑποστάτης ἐστί.

[11] MS **O** is full of copying errors of every kind; for general discussion of this famous manuscript see Wilson 1978 and note O'Meara's own assessment (O'Meara 1989: XV).

Above the letters εἴπ- we see οι spelling εἴποι and then above μ- we see another οι, which spells μοι, when in fact the proposed emendation would have -μι. Why did it take a machine to spot the mistake given the source of Psellos' argument, i.e. his commenting on Synesius, was known? Without wishing to indulge in excessive speculation, it is worth noting that first-person optatives such as εἴποιμι are much rarer than the corresponding third person forms – surely one more factor that induced the error in the first place.[12] Is it possible that this also helped protect the stylistically and contextually poor reading εἴποι μοι from excessive scrutiny on the part of modern scholars?

More important than raw statistical likelihood is surely another consideration which brings into focus an important difference between exclusively human and machine-assisted philology. Correcting εἴποι μοι to εἴποιμι requires us to read across word boundaries in a way that human philologists tend to find challenging. As users of modern print editions, we forget that word boundaries barely exist in ancient Greek texts and are not always easy to establish with certainty even in the medieval manuscripts.[13] Logion is not trained to reckon with word boundaries and therefore has no such difficulties. At present, it is hard to quantify how often Logion does better than humans at recognizing problems with word division, but in purely qualitative terms we can say that interventions on such problems are among Logion's most intuitively satisfying.[14]

[12] A TLG search yields the following statistics for the corpus as a whole: 3rd pers. sg. opt. (top five only) 107,910; 1st pers. sg. opt. (top five only) 5,389. For εἰπεῖν the figures are: 9098 (εἴποι) and 1529 (εἴποιμι). Note, however, that within the digitized oeuvre of Psellos εἴποιμι outnumbers εἴποι at a ratio of almost 3:2 (149:108).

[13] The challenges posed by word division have attracted a fair amount of comment; see West 1973: 26, 54, 149-50.

[14] Two further examples may serve to illustrate the point: In *Or. pan.* 17.839 Dennis prints ἵνα τ' ἀκριβὲς εἴποιμι, with puzzling use of elision. Logion suggests τἀκριβὲς, with crasis, which must be correct and is indeed what we find in the only extant manuscript, Paris, Bibliothèque nationale de France, Grec 1182 f. 179r; cf. *Theol.* I, 62.67-68 Gautier ἵνα τἀκριβέστερον εἴπω. Then again, in *Comm. Ar. Phys.* 383,10 Benakis [2008] prints τὸ αὐτοκινοῦν, ostensibly a form of the rare verb αὐτοκινέω. Logion proposes τὸ αὐτὸ κινοῦν, as written in the important MS **L**; for further details and discussion see below: 70-90.

2.

Language models like Logion, I have argued, can help us see past reading habits that may otherwise be difficult to shed. As users of printed texts, we often find it hard to question where one word begins and the other ends – until someone or something invites us to consider specific possibilities. Not sharing our habits of reading, artificial intelligence can perform this task for us. Philological bias, however, extends beyond the fairly basic questions of layout that I have considered so far. As modern readers of pre-modern texts we carry with us a whole array of intellectual and cultural preconceptions which machine-learning algorithms like Logion can help us address, as other chapters in this volume illustrate.[15] Here I single out a specific form of bias that is of interest to the present argument because it goes to the very heart of philology as a discipline: the bias that arises from hard-won philological expertise.

[Psellos] *Poem.* 53.591-603 Westerink recounts the famous story of how Hebrew scripture was translated into Greek. It is taken from a poem that was transmitted alongside those of Psellos but is probably not by him.[16] Logion flags the plural ἔφησαν in line 599 as suspicious and suggests the singular ἔφησε instead, which is in fact found in one manuscript, Westerink's MS **p**.[17] A third manuscript, Westerink's MS **v**, has the syntactically inferior ὃς ἔφη. Logion was not aware of any variants but by recommending one of them prompts us to reconsider the text as its most recent editor reconstructs it:[18]

ἀναγνωσθείσης γάρ φασι τῆς ὅλης ἑρμηνείας
εἰς θάμβος καὶ κατάπληξιν ἐλθεῖν τὸν Πτολεμαῖον
θαυμάσαντα τὴν δύναμιν τοῦ λόγου καὶ τὸ κάλλος.
ἐπαπορῶν δ' ὁ βασιλεὺς ἠρώτα τοὺς παρόντας,
πῶς οὐκ ἐχρήσαντό τισιν ἐκ τούτων τῶν γραμμάτων 595

[15] For an instructive example of cultural bias see May and Ozbek, chapter 7 in this volume.

[16] Westerink 1992: 303.

[17] Westerink follows MS **s** in printing ἔφησαν. For the reasoning behind this decision see: 68-9 below.

[18] Already Lambros and Dyobouniotes 1922: 378 had printed ἔφησαν, in an edition based solely on Cod. Vindob. theol. 213, which is a copy of MS **s** (Westerink 1992: XXVII).

ἱστορικοὶ καὶ ποιηταὶ καί τινες τῶν ὁμοίων.
Δημήτριος δ' Ἀλιφαρεὺς παρατυχὼν ἐν τούτῳ–
παρῆν δὲ καὶ Μενέδημος, ἀνὴρ τῶν φιλοσόφων–
ἔφησαν μή τινα τολμᾶν ἅπτεσθαι τῶν τοιούτων·
λέγουσι γὰρ Θεόπεμπτον τὸν ἱστοριογράφον
μνησθέντα τούτων ἐν γραφαῖς εὐθὺς παραφρονῆσαι·
σὺν τούτῳ καὶ Θεόδεκτον αὐτοῖς ἐπιβαλόντα,τὸν
τραγῳδίας ποιητήν, αὐτίκα τυφλωθῆναι·

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599 ἔφησαν **s**: ἔφησε **p** ὃς ἔφη **v**

For, they say, when the entire translation was read out Ptolemy fell into a state of awed admiration, marveling at the power and beauty of the discourse. And in his perplexity, the king asked those who were present how come historians, poets and other authors did not quote from these writings. Demetrius of †Alipharon (i.e. Phaleron) who happened to be present at the time – also present was the philosopher Menedemus – said that no-one had dared touch them. For allegedly the historian Theopemptus (i.e. Theopompus) mentioned them in his work and immediately lost his mind. Likewise, the tragedian Theodectus cited them and straightaway went blind.

Logion flags ἔφησαν as suspect and suggests ἔφησε instead.

The strongest argument in favor of adopting the reading in MS **p** comes from earlier accounts of the episode. The 10th-century historian Symeon Magister writes (*Chronicon* 47.4 Wahlgren):

τῆς θείας οὖν γραφῆς ἑρμηνευθείσης καὶ ἀναγνωσθείσης ἐκπλαγῆναί τε τὸν βασιλέα ἐπὶ τῷ κάλλει τῶν θείων λογίων καὶ πάντας τοὺς ἐν τέλει. παρόντος οὖν Μενεδήμου φιλοσόφου καὶ Δημητρίου Φαληρέως καὶ θαυμαζόντων τὴν δύναμιν τῶν λόγων ἠρώτησεν ὁ βασιλεύς, ὅτι τοιούτων ὄντων τῶν θείων λόγων, πῶς οὐδεὶς ἱστορικῶν ἢ ποιητῶν ἐμνήσθη αὐτῶν; καὶ ἀπεκρίθη Δημήτριος, ὅτι οὐδείς ποτε ἐτόλμησεν τούτων ἅψασθαι, διὰ τὸ καὶ Θεόπομπον (var. lect. Θεόπεμπτον) θελήσαντα ἱστορῆσαι περὶ αὐτῶν παραφροσύνῃ κρατηθῆναι καὶ ὄναρ ἰδεῖν, ὅτι τοῦτο αὐτῷ συμβέβηκε περιεργασαμένῳ τὰ θεῖα κτλ.

When the divine scripture had been translated and read out, they say the king and all his notables were struck by the beauty of the divine utterances. Among those present were the philosopher Menedemus and Demetrius of Phaleron, who admired the power of the words. The king then asked

how come, given the divine words were of such a kind, no historian or poet mentioned them. Demetrius answered that no-one ever dared touch them because Theopompus (variant Theopemptus) wanting to write about them went mad and dreamed that this had happened to him because he had meddled with divine things, etc.

The anecdote of Ptolemy, Demetrius, and Menedemus was popular in Byzantium, so our anonymous poet could have taken it from any number of sources. What matters here is that all major prose versions of the story, including Symeon Magister's account, have Demetrius alone reply to the king.[19] There is thus a strong presumption that our poet too kept to the singular, and a close reading of the passage confirms that this is indeed what he must have done: after the participle παρατυχών in line 597, line 598, which begins with the main verb παρῆν followed by δέ, must be a new parenthetical sentence (as Westerink acknowledges by enclosing it in dashes). If that is so, the sentence beginning in line 597 has one subject, Demetrius, and the main verb must therefore be in the singular. MS **p**'s ἔφησε is then the correct reading – which raises the question of why it is that the plural reading was preferred in the critical edition.

Logion, I have already noted, has no knowledge of manuscript variants. One might think this a fatal limitation to its usefulness, but in the example presented here the opposite is arguably the case. Leendert Gerrit Westerink (†1990), one of the foremost editors of Psellos, appears to have misjudged the passage in question precisely because he had a secure grip on the relevant manuscripts and definite views on them. He writes about MS **s**, whose reading he prefers:[20]

codex multa cum cura exaratus, quem in edendo textu praecipue secutus sum.

This manuscript is written with great care, and in editing the text I have followed it for the most part.

[19] Cf. George Hamartolus, *Chron. brev.* PG 110: 348.26 καὶ ἀπεκρίθη Δημήτριος; George Cedrenus, *Comp. hist.* I, 290.5 (Bekker) καὶ ἀπεκρίθη ὁ Δημήτριος.

[20] Westerink makes these comments in his edition of *Poem* 1 (1992: IX). On MS **s** more generally see also his remarks on page VIII.

By contrast, Westerink has this to say about MS **p**, whose reading he rejects:[21]

hic quoque codex, quamquam Monomacho carmen inscribit, deterioribus adnumerandus est. desunt vss. 649-1201; nimirum scribam, cum dimidium fere poema descripsisset, laboris piguit, quamobrem reliquis omissis ad epilogum transiit.

This manuscript too, although it contains a dedication to Monomachus, must be counted among the inferior ones. Lines 649-1201 are missing: no doubt the scribe got fed up after copying about half the poem and, skipping the rest, went straight to the epilogue.

Westerink considers **p** an 'inferior' manuscript, partly it seems on the ground that it contains large gaps.[22] That general assessment, however, should not prevent serious consideration of its readings.[23] As West notes, the quality of a manuscript 'can be used as a criterion only when other criteria give no clear answer'.[24] In our case, we do have a clear answer, and Logion draws attention to it.

What we see here is another case of human bias affecting our ability to make good editorial decisions – arising this time not from mere habits of reading and our tendency to take word divisions for granted, but rather from hard-earned philological expertise on which manuscripts seem more reliable. The phenomenon of trusting such manuscripts even in cases where they contain errors has long been identified as a problem but despite many warnings it remains stubbornly per-

[21] Westerink 1992: X (on *Poem* 2). For further details see his comments on page VIII: "Parisinus gr. 2875, s. XIII: Poem. 53 (ff. lr-2v); 5 (ff. 3r-v); 4 (ff. 3v-5v); 2 (ff. 5v-11v); 3 (ff. llv-12v); separatim 24 (ff. 140v-143v)".

[22] Compare his comments on *Poem* 3, Westerink 1992: XIII: "*desiderantur in hoc codice* [sc. Paris, Bibliothèque nationale de France, Grec 2875] vss. 65-82, *id quod casu factum esse non potest, cf. quod supra dictum est de magna parte Poem. 2 consulto praetermissa*".

[23] The precise relationship between MSS **s** and **p** is unknown but there is reason to believe that the latter represents an independent branch of the tradition and that ἔφησε is therefore not a scribal conjecture. Among several superior readings in **p** that are not easily explained as the result of ad hoc scribal correction one might single out *Poem* 53.657 δὴ μηνίσας **p v**: δημηρίσας **s**.

[24] West 1973: 50.

sistent:[25] to know that one manuscript is 'better' than another and not get distracted by that knowledge is a difficult thing for human editors to do. Machines do not have this problem because they lack the contextual knowledge that induces human scholars to form biases for or against specific manuscripts. Logion is fundamentally insipid and can do nothing without human expertise. But, by the same token, it can act as a useful check on precisely that expertise.

3.

Machine learning algorithms are not just useful in drawing attention to specific manuscript readings that have been neglected, as in the last example. They can also help reassess wider issues in manuscript studies. I conclude this chapter by looking at a particularly serious case of editorial bias, this time against a manuscript that deserves more credit than it has received. At issue is the commentary on Aristotle's *Physics* that has sometimes been attributed to Psellos. The following passage was the starting point for the investigation presented here (376,28-377,3 Benakis):

Ὁμοίως δὲ καὶ τὸ ποιὸν δυνάμει εἰς τὸ ἐνεργείᾳ μεταβάλλει· γέγονε γὰρ **ἐν** δυνάμει ἐπιστήμονος ἐπιστήμων ἐνεργείᾳ καθ' ἕξιν, καὶ θεωρεῖ κατ' ἐπιστήμην ἐὰν μὴ ἐμποδίζηται.

And in the same way a quality that is potential gets transformed into one that is actual. For in the potentiality of the expert (?) an actual expert comes about through trained habit, and he observes according to his expertise unless he is prevented from doing so.

Logion flags ἐν as suspect and suggests ἐκ instead.

The author of the commentary – more on him in a moment – explains how a potential quality (τὸ ποιὸν δυνάμει) changes into an actual one (εἰς τὸ ἐνεργείᾳ μεταβάλλει). For illustration, he cites an example which he lifts from Aristotle: a potential expert becomes an actual expert by reasoning like one (κατ' ἐπιστήμην). Logion's ἐκ δυνάμει ἐπιστήμονος, 'from someone potentially expert' corresponds to εἰς τὸ ἐνεργείᾳ, 'into

[25] For Housman on the 'application of thought' see Battezzato 2021. Also relevant is Pasquali's call not to dismiss entire groups of manuscripts out of hand, see Pasquali 1934.

something actual': each formulation captures the transition from one state to another. All that makes good sense and is in line with what Aristotle argues in the *Physics*.[26] By comparison, it is hard to make sense of the text of the commentary as Benakis prints it. What could it mean to say that an actual expert comes about 'in the potentiality of an expert'? Even if one might imagine ways of interpreting this formulation in a different context, within the context of the *Physics* commentary it introduces a stark non sequitur, for the author has not been asking what happens ἐν δυνάμει but rather how something that exists potentially (τὸ δυνάμει) attains actuality (εἰς τὸ ἐνεργείᾳ μεταβάλλει).[27]

Now, it turns out that the oldest available manuscript, MS **L** (Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5), in fact reads ἐκ δυνάμει ἐπιστήμονος, as suggested by Logion, not ἐν δυνάμει ἐπιστήμονος as printed by Benakis, who follows later manuscripts. Moreover, MS **L** also reads εἰς, not the meaningless ὡς, in the phrase εἰς τὸ ἐνεργείᾳ μεταβάλλει earlier in the same sentence – 'pace' Benakis who records εἰς as his correction for transmitted ὡς τὸ ἐνεργείᾳ μεταβάλλει.[28] Cf. MS **L** f. 133r:

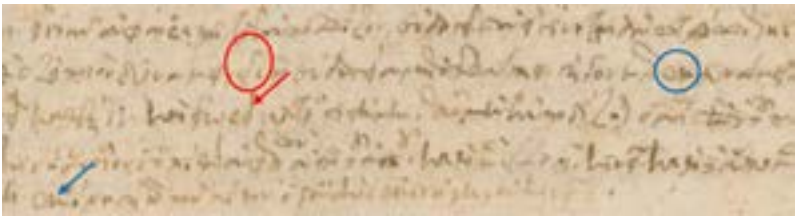

Fig. 2. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 133r.
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The sigma in εἰς is unusually straight (red circle) and the kappa in ἐκ has a squashed appearance (blue circle). But ει in εἰς is confirmed by the same diphthong, written in the same way, in the following line (red arrow); and the squashed kappa in ἐκ is recognizably the same letter as in ἐκίνησε three lines further down (blue arrow). MS **L**, then, preserves the correct text of the passage, with Logion and against the other manuscripts.

What we have here is the machine prompting us not just to reevaluate known manuscript readings but also to clarify what those readings

[26] Ar. *Phys.* VIII 4, 255 b 1ff.

[27] Benakis 2008: 376,1-2.

[28] Benakis 2008: 376, *app. crit.*

actually are. We see more examples of this elsewhere in the volume, each of them valuable in its own right. For the purposes of the present argument, I focus not on individual cases of misreported manuscripts but on the more fundamental questions they raise. Specifically, I ask whether it is pure coincidence that MS **L** alone preserves the correct text twice in one sentence. Scholars have disagreed about the value of MS **L**, but not about who wrote it: as Harlfinger has shown, the manuscript is the handiwork of the 13th/14th-century philosopher and polymath George Pachymeres.[29] Was Pachymeres also the author of the commentary, as Golitsis has argued on codicological grounds or was he copying out a commentary written by Psellos?[30]

Golitsis' argument has found widespread approval but has not convinced everyone. Notably, the editor of the *Physics* commentary, Linos Benakis, sought to prove that MS **L** goes wrong too often and too egregiously to qualify as an author copy. In support of his skepticism, he assembled a list of what he considered to be scribal errors in MS **L**.[31] The list, on first reading, seems impressive and thus successfully undermines our faith in the manuscript (and therefore its potential status as an author copy). However, on closer inspection, the errors listed turn out to be explicable or, in fact, not errors at all. I reproduce Benakis' complete list here, together with some brief comments:

8,10 οὐδὲν λύεται τὸ συμπέρασμα pro οὐδὲν κωλύεται τὸ συμπέρασμα – 'Pace' Benakis, MS **L**'s λύεται, rather than κωλύεται, is the correct reading; cf. Aristotle, *Topica* 160b 28-29 ἀναιρεθέντος οὖν τοῦ Σωκράτη καθῆσθαι οὐδὲν μᾶλλον λέλυται ὁ λόγος.

34,8 εἰ καὶ αὐτὸς ταῦτα ἔλεγεν pro ἢ καὶ αὐτὸς – MS **L**'s ἢ (... ἢ) is idiomatic in combination with οὐκ οἶδα in both Psellos and Pachymeres and should be adopted; cf. Psellos, *Ep.* 309.6-9 Papaioannou Ἐμὲ δὲ (ὡς οἶδας) ἐπισύρονται πολλοὶ εἰς τὰς ἀξιώσεις, οὐκ οἶδα ἢ ὡς πάντας ἀγαπῶντα, ἢ ὡς παρὰ πολλῶν ἀγαπώμενον, Pachymeres, *Hist. brev.* 4.32.17-18 οὕτω δικαιώσας ὀφθῆναι τῷ βασιλεῖ, οὐκ οἶδα ἢ κατὰ λύπην ἰδίαν ἢ καὶ διὰ τὴν ἐκείνου ἐκμείλιξιν.

35,2 ἓν ἀριθμὸν pro ἓν ἀριθμῷ – MS **L**'s ἓν ἀριθμὸν ὑπάρχουσαν for Aristotle's ἓν ἀριθμῷ ὄν (*Cat.* 4a 10-11) does look like a slip, but it is the kind of slip that can easily happen to a busy commentator, espe-

[29] Harlfinger 1996.

[30] Golitsis 2007.

[31] Benakis 2008: *49-*50, n. 74.

cially when his mind is distracted by other thoughts. Ours evidently wished to refocus Aristotle's formulation (τὸ ταὐτὸν καὶ ἕν [...] ὄν) by stressing the role of οὐσία, replacing ὄν not with οὖσαν but with the more emphatic ὑπάρχουσαν.[32] Amidst these deliberate transformations, a further unwanted change crept in that was evidently induced by homoioteleuton (τὸ ταὐτὸν καὶ ἕν ἀριθμὸν κτλ).[33]

37,16(-17) σὺν τρίτῳ ὑποκειμένῳ τὴν ὕλην pro ... τῇ ὕλῃ – MS **L**'s τὴν ὕλην is in fact correct, and Benakis rightly adopts it in his text.

48,3 τὸ ὑπομένον pro τὸ ὑποκείμενον – ὑπομένον (MS **L**) is correct, not ὑποκείμενον as in the other manuscripts; cf. Aristotle, *Physics* 190a 9-21.

49,2 ἐπὶ τῶν οὐσιῶν μόνων ὄν pro ἐπὶ τῶν οὐσιῶν μόνον ὄν – MS **L**'s (and **A**'s) μόνων must be right: it appears in the text of Aristotle's *Physics* found in MS **L** and goes back to an ancient variant attested in MS I, Philoponus (lemma) and perhaps Simplicius.

56,15 διττῶς pro διχῶς Arist., codd. – MS **L**'s διττῶς (*Sic*; cf. f. 16r. Benakis reports διττοῦς in his *app. crit.*) is a deliberate departure from the base text in a passage where the author is glossing, not quoting, Aristotle. That other manuscripts normalize to Aristotle's διχῶς should come as no surprise.

66,21 πρώτως pro πρῶτον Arist., codd. – πρώτως ἀρρύθμιστον (**L**) seeks to clarify a difficult passage in Aristotle (τὸ πρῶτον ἐνυπάρχον ἑκάστῳ ἀρρύθμιστον, II 1, 193a 10-11) by replacing an ambiguous form. Reintroducing πρῶτον from Aristotle, as Benakis does following other manuscripts, results in an inferior text.

73,12 (*Sic.* Benakis references 76,24) ἡ αὐτὴ καὶ μετὰ pro ἡ αὐτὴ καὶ μία – MS **L** in fact reads μία (below, red circle), not the nonsensical μετὰ reported by Benakis (f. 21v):

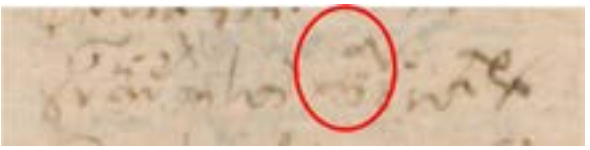

Fig. 3. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 21v.

[32] ἀριθμῷ in MSS **B** and **C** may then be the result of harmonization with Aristotle's text.

[33] Pachymeres, for one, was not above making mistakes of this kind, as Concetta Luna points out to me. She cites an example from his continuation of Proclus' Parmenides commentary; cf. Gadra et al. 1989: 36.25, where Pachymeres writes τὸ προκείμενα in the autograph copy Paris, Bibliothèque nationale de France, Grec 1810 and the editors correct to τὸ προκείμενον.

82,8 ἐντελές pro ἐντελεχές – Given the context (II 3, 195b 3-6), ἐντελές (**L**) seems preferable to ἐντελεχές; cf. Pachymeres, *Comm. Ar. Met.* 74.15-19 Pappa.

187,20(-1) τοῦ μὴ λέγειν pro τοῦ λέγειν Arist, codd. – 'Pace' Benakis, MS **L**'s μή is necessary: the author explains why Aristotle says ἐν ᾧ μηδέν ἐστι and *not* ἐν ᾧ μηδέν ἐστι σῶμα.

190,3 (*Sic.* Benakis references 190,2) τῶν τοιούτων διαστήματος pro τοῦ τοιούτου διαστήματος – 'Pace' Benakis, τῶν τοιούτων, 'of such things' (**L**), is better than τοῦ τοιούτου, which arose from attraction to διαστήματος.

214,2 λάμβανε pro λαμβάνεται – λάμβανε (**L**) seems right; cf. 214,14 Benakis (λάμβανε again).

215,8 εἰς ἄπειρον pro εἰς ἄπειρα – **L**'s ἄπειρον is the better text; cf. Ar. *Phys.* 200b 20 ὡς τὸ εἰς ἄπειρον διαιρετὸν συνεχὲς ὄν.

217,11 ἡ δυάς pro οἱ δύο Arist., codd. – ἡ δυάς (**L**) must be printed since the author signals a quotation from Aristotle and ἡ δυάς is what Aristotle says at *Phys.* 220a 27 ('pace' Benakis).

218,11 καὶ ἕτερος καὶ ἕτερος pro καὶ ἕτερα καὶ ἕτερος – ἕτερος καὶ ἕτερος (**L**) is certainly correct. The commentator explains *Phys.* IV 12, 220 b8-10: time is always different (ἀεὶ ἕτερος) for the moments are different (τὰ γὰρ νῦν ἕτερα). He thus correctly takes ἀεὶ ἕτερος as ἕτερος καὶ ἕτερος; cf. John Philoponus *In Phys.* 744.14-16 νῦν δὲ οὐκ ἔστιν ὁ ἀριθμῶν, ἀλλ' ὁ ἀριθμούμενος, ὥστε ἕτερος καὶ ἕτερος ὁ παρεληλυθὼς καὶ ὁ μέλλων.

317,13 ὁ λέγων pro ὁ λόγος – MS **L**'s ὁ λέγων (f. 108v) is preferable to ὁ λόγος in the other MSS: Zeno as personal subject chimes with past tense in κατεσκεύαζε, and at issue is in any case not one λόγος but several; for the formulation with ὁ λέγων cf. Pachymeres, *In Met.* 31.12, 82.12.

362,22 (*Sic.* 326,23 Benakis) ὁμονοητῶς pro ὁμονοητικῶς – 'Pace' Benakis, MS **L** (f. 127r) actually reads ὁμονοητικῶς, not the unparalleled ὁμονοητῶς, using the same abbreviation (red arrow) employed earlier for ὑποθετικῶς (blue arrow) and δεικτικῶς (green arrow):

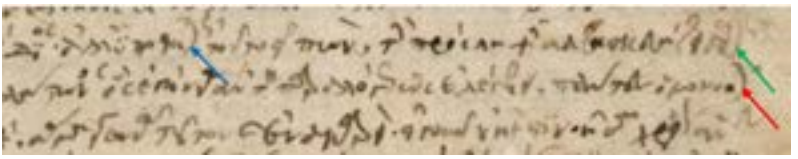

Fig. 4. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 127r.

MSS **A** ("non vidi"), **C** and **D** ("non vidi"), which read ὁμονοητῶς, either themselves misread or depend on a witness that misread a similar abbreviation. Michael Apostolios, the scribe of the Parisian MS **B**, correctly spells ὁμονοητικῶς. He may have read more carefully, worked with a clearer *Vorlage*, or else corrected what he realized was a faulty text.

394,8 οὔτε pro ἅτε – 'Pace' Benakis, MS **L** in fact reads ἅτε, which is correct, not the nonsensical οὔτε. Compare word-initial alpha in ἅτε (red arrow) with ἅμα as written in the right-hand margin of MS **L** f. 85r (blue arrow):

Fig. 5a. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 139v.
Fig. 5b. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 85r.

425,4 (*Sic.* Benakis references 425,5) κατὰ τὴν ἀναλογίαν τῆς ἀναστροφῆς pro κατὰ τὴν ἀναλογίαν τῆς ἀντιστροφῆς – ἀναστροφῆς for ἀντιστροφῆς does look like an error in MS **L**, but it is the kind of error that an author would make, near the end of a text, at the end of a section, and immediately after a similar-sounding word (homoearchon): note κατὰ τὴν ἀνα<u>λ</u>ογίαν τῆς ἀνα<u>α</u>στροφῆς. We can imagine several ways in which later copyists arrived at what looks like the correct text.[34]

As may be seen from this brief review, very few of Benakis' passages attest to actual corruption in the text of MS **L**. The few errors in his list that bear philological scrutiny are as likely to have been made by the author of the commentary as by a scribe copying the work of someone else. Tellingly, among these alleged errors, there are several passages where MS **L** turns out to preserve superior readings. In addition, there are cases where the readings in **L** singled out by Benakis help to explain what we then find in the later manuscripts, suggesting dependence ei-

[34] As Concetta Luna points out to me, almost anyone could have taken ἀντιστροφή two lines above (425,2 Benakis) and improved the text on that basis; see also 424,11 Benakis ἀντιστρόφως. Most economically, perhaps, we might hypothesize that the lost Escorialensis Δ.IV.24 already contained the correct reading. See Golitsis 2007: 668, 670 on the status of that manuscript as "une sorte d'édition officielle".

ther on **L** itself or on a similar manuscript. There are also signs that the commentary is based on the idiosyncratic Aristotelian base text included in MS **L**, but not in the other manuscripts. While none of this *proves* that MS **L** is an author copy, the considerations offered here suggest that we should pay more careful attention to this manuscript. We can further strengthen these initial observations by considering other passages where Logion sides with MS **L** against Benakis and/or the other manuscripts. I review them below, again with brief annotations. Manuscript readings that are misreported or omitted in Benakis are marked with an asterisk. The digitized Parisini graeci 1920 (**B**) and 1947 (**C**) serve as controls.[35]

15,14 καὶ ἄλλο τῷ ἀνθρώπῳ εἶναι Benakis, MSS **B**, **C**: καὶ ἄλλο τὸ ἀνθρώπῳ εἶναι MS **L**, suggested by Logion. τὸ ἀνθρώπῳ εἶναι is plainly correct, judging by context and the parallels in Aristotle (*Anal. priora* 91b 6, *Met.*1006a 33, etc.).

19,21 αὐτῇ Benakis, MSS **B**, **C**: αὐτῶν MS **L**, suggested by Logion. αὐτῶν must be correct. The commentator is paraphrasing *Phys.* I 3, 186b 3 ὥστε εἶναί τι ἕκαστον and wants to explain what ἕκαστον is. So he writes αὐτῶν ἑκάτερον and then specifies: τὸ ὑποκείμενον καὶ ὃ συμβέβηκεν.

22,15 τὸ ὅπερ ὃ Benakis: τὸ ὅπερ ὂν MS **L*** (*Sic.* Benakis reports τὸ ὅπερ ὃ), suggested by Logion. ὂν is clearly correct; cf. Arist. *Phys.* 186b 14 ὅτι δὲ διαιρεῖται τὸ ὅπερ ὂν ... The text of 22,14-17 Benakis is only attested in MS **L**, between the lines and in the margins of the main commentary text. As Concetta Luna points out to me, it is written by a different hand from that of Pachymeres and disrupts the syntactical and logical flow of the passage.[36] It is not part of Pachymeres' text and should not have been printed in Benakis' edition.

MS **L** f. 5v:

[35] Paris, Bibliothèque nationale de France, Grec 1920 and Grec 1947. Images are courtesy of the Bibliothèque nationale de France. For discussion see Benakis 2008: 51*.

[36] ἀνάπαλιν γάρ (17) ought to follow immediately after ἀλλὰ καὶ τοῦτο ἀδύνατον (13-14) because the commentator is paraphrasing *Phys.* 186b 30-31 ἀλλ᾽ ἀδύνατον· ἐκεῖνο γὰρ ἐν τῷ ἐκείνου λόγῳ ἔνεστιν. As things stand, line 17 εἰς τὰ ἅπερ ὄντα ἀνάπαλιν γάρ is bereft of meaning (Concetta Luna, *per litteras*).

Fig. 6. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 5v.

87,17 πολλὰ τυχαίως γενόμενα Benakis, MSS **B**, **C**: γινόμενα MS **L***, suggested by Logion. Context confirms that γινόμενα must be correct.

MS **L** f. 26v:

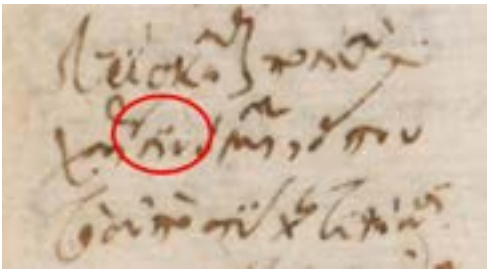

Fig. 7. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 26v.

134,7-8 Benakis relegates **L**'s reading γε (shared by MS **D**, "non vidi") to the *app. crit.*, but Logion, without knowledge of the variant, suggests γε, which is clearly preferable.

244,25 τὸ εἰς ὃ τὸ ἐξ οὗ, ὅτι εἰς ἐπιστήμην Benakis, MS **B**: τὸ εἰς ὅτι ἐξ οὗ Benakis in *app. crit.*, MS **C**: τὸ εἰς ὃ τῷ ἐξ οὗ MS **L***, suggested by Logion. Only τῷ ἐξ οὗ can be correct.

MS **L** f. 79v:

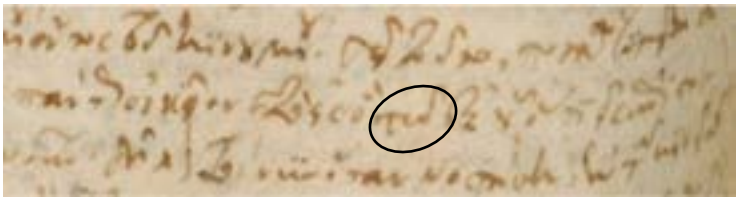

Fig. 8. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 79v.

251,29 ἀπὸ τὸ συνεχόμενόν ἐστι Benakis, MSS **B**, **C**: ὑπὸ MS **L***, suggested by Logion. ἀπό with accusative is outside the stylistic range of either Psellos or Pachymeres. ὑπό must be right.

MS **L** f. 81v:

Fig. 9. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 81v.

MS **B** 81r:

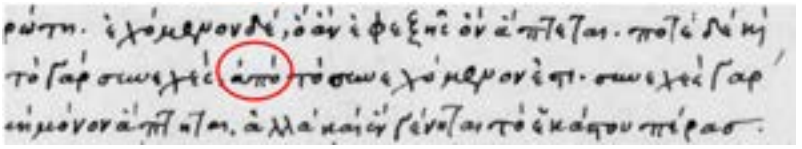

Fig. 10. Paris, Bibliothèque nationale de France, Grec 1920, f. 81r

MS **C** 158v:

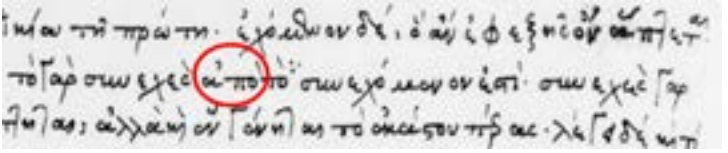

Fig. 11. Paris, Bibliothèque nationale de France, Grec 1947, f. 158v.

255,25 Τῷ [*sic*] δὲ τῷ γένει μίαν κίνησιν εἶναι οὕτω λάβε Benakis, who notes in his *app. crit.* 'τῷ γένει L: γένει ceteri'. The true situation is as follows: τὸ δὲ τῷ γένει MS **L***: τῷ δὲ γένει MSS **B***, **C***. (See images below). MS **L**'s text, which was suggested by Logion, is clearly correct.

MS **L** f. 83r:

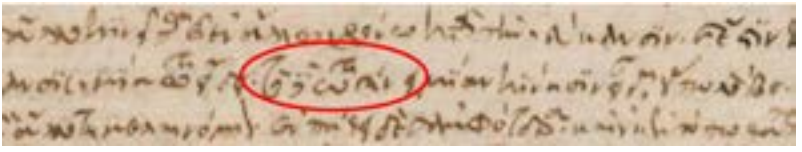

Fig. 12. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 83r.

MS **B** f. 82v:

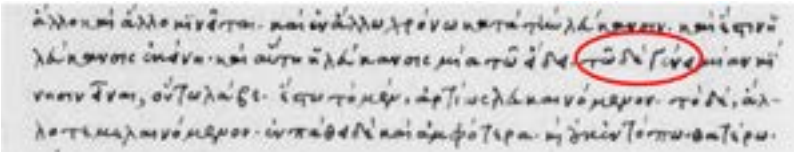

Fig. 13. Paris, Bibliothèque nationale de France, Grec 1920, f. 82v.

MS **C** f. 159v:

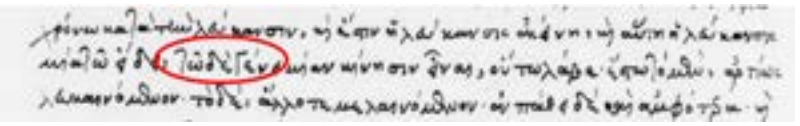

Fig. 14. Paris, Bibliothèque nationale de France ?, Grec 1947, f. 159v.

261,11 Benakis reports the inferior reading ἡ for MS **L** (i.e. διαφοραὶ ἡ εἰς), against εἰ in the other MSS (i.e. διαφοραὶ εἰ εἰς). He even prints ἡ, but this is not viable Greek and **L*** in fact reads εἰ (below, red arrow). The issue came to light because Logion recommended replacing ἡ with εἰ.

MS **L** f. 84v:

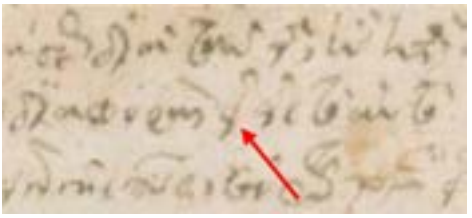

Fig. 15. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 84v.

264,10 Benakis prints the impossible ἐναντίαι and reports the reading ἐναντία in MS **B**. Without knowledge of MS **B**, Logion suggests ἐναντία which is also in MS **L*** and should be printed.

MS **L** f. 85r:

Fig. 16. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 85r.

MS **B** f. 85v:

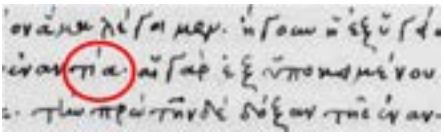

Fig. 17. Paris, Bibliothèque nationale de France, Grec 1920, f. 85v.

MS **C** f. 162r:

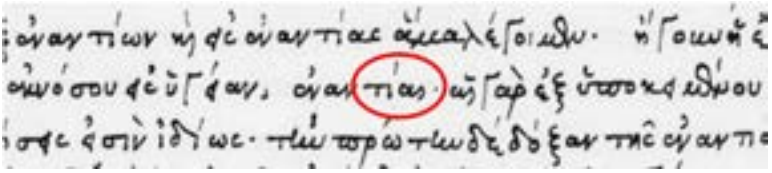

Fig. 18. Paris, Bibliothèque nationale de France, Grec 1947, f. 162r.

332,24 εἶτα κινούμενα Benakis, MSS **B**, **C**: εἰ τὰ κινούμενα MS **L***, suggested by Logion. εἰ τὰ rather than εἶτα is clearly what Pachymeres originally wrote (cf. εἰ three lines down). But then he changed his mind and replaced the entire passage ἐφ' οὗ καὶ μᾶλλον [...] συνάγεται τὸ ἀδύνατον (332,23-5 Benakis) with a different text written in the extreme right-hand margin of the manuscript (see image below).[37]

MS **L** f. 115r:

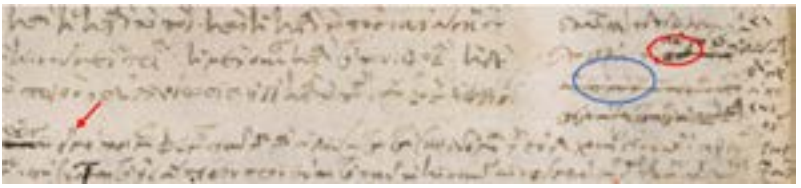

Fig. 19. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 115r.

Detail of previous image (εἰ *ante corr.*):

[37] I thank Concetta Luna for pointing this out to me. A review of the paradosis brought to light another error in Benakis [2008] and the control MSS: for ἐν τῷ αὐτῷ later in the same sentence MS **L** has the correct ἐν αὐτῷ (blue circles).

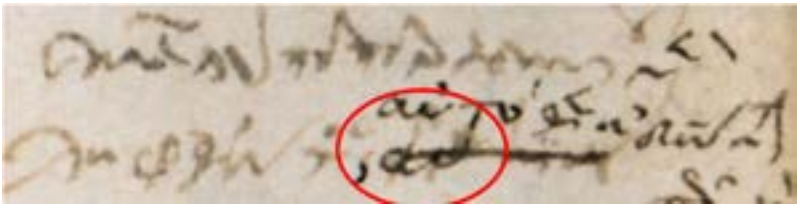

Fig. 20. Detail of previous image (εἰ *ante corr.*) – Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 115r.

Contrast the different shape of εἶ in εἶναι earlier on the same page (MS **L** f. 115r):

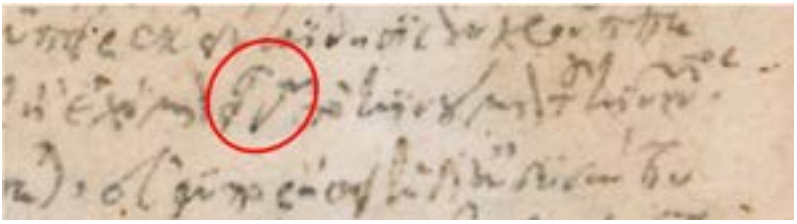

Fig. 21. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 115r.

The control manuscripts **B** and **C** unambiguously read εἶτα. Cf. MS **B** f. 107v:

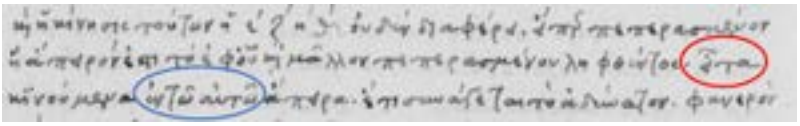

Fig. 22. Paris, Bibliothèque nationale de France, Grec 1920, f. 107v.

And MS **C** f. 182r:

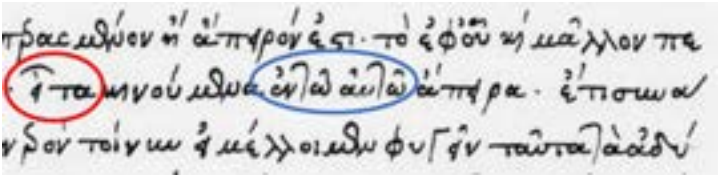

Fig. 23. Paris, Bibliothèque nationale de France, Grec 1947, f. 182r.

370,7 περὶ τοῦτον Benakis, MS **C**: περὶ τοῦ τὸν MSS **B***, **L***, suggested by Logion. Context confirms that περὶ τοῦ τὸν must be read.

MS **L** f. 130r (note the grave accent on τὸν):

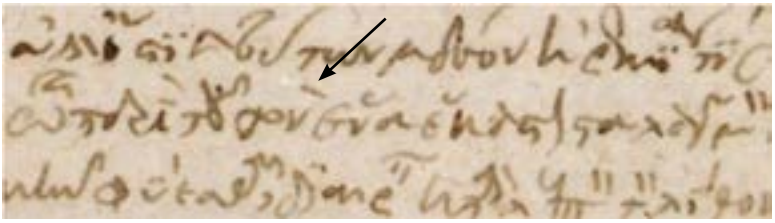

Fig. 24. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 130r.

MS **B** f. 120v (NB grave accent):

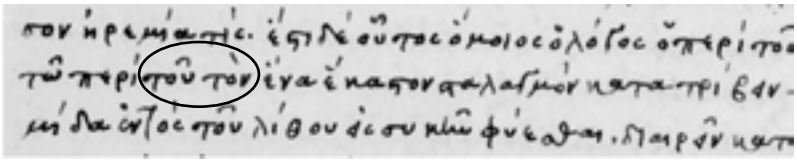

Fig. 25. Paris, Bibliothèque nationale de France, Grec 1920, f. 120v.

MS **C** f. 193v:

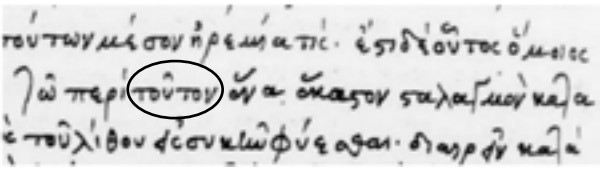

Fig. 26. Paris, Bibliothèque nationale de France, Grec 1947, f. 193v.

379,3 χερὶ Benakis, MS **B**: χειρὶ MSS **C**, **D** ("non vidi"), ***L**, suggested by Logion. χειρὶ must be right since Aristotle, Pachymeres, and Psellos all use this form.

MS **L** f. 134r:

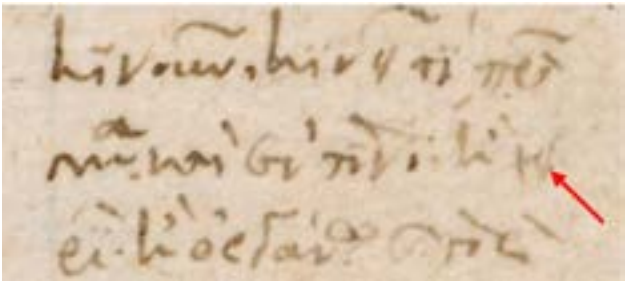

Fig. 27. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 134r.

MS **B** 124r:

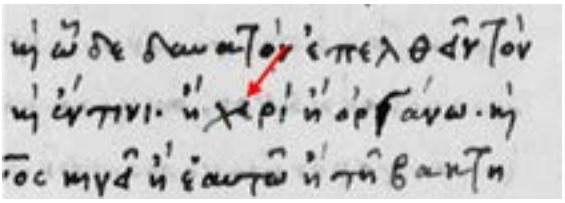

Fig. 28. Paris, Bibliothèque nationale de France, Grec 1920, f. 124r.

MS **C** f. 196v:

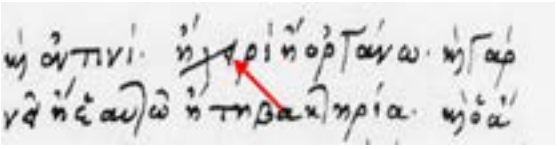

Fig. 29. Paris, Bibliothèque nationale de France, Grec 1947, f. 196v.

383,10 τὸ αὐτοκινοῦν Benakis, MSS **B**, **C**: τὸ αὐτὸ κινοῦν MS **L***, suggested by Logion. τὸ αὐτὸ κινοῦν is correct, cf. Ar. *Phys.* 257a 29, 257b 2 (τὸ αὐτὸ αὐτὸ κινοῦν).

MS **L** f. 135v (notice rough breathing, grave accent):

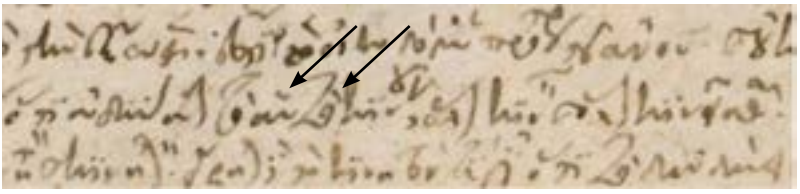

Fig. 30. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 135v.

MS **B** f. 125r (smooth breathing, no grave accent):

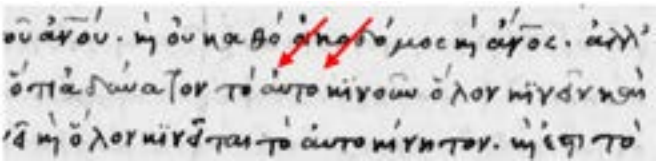

Fig. 31. Paris, Bibliothèque nationale de France, Grec 1920, f. 125r.

MS **C** f. 197r (smooth breathing, no grave accent):

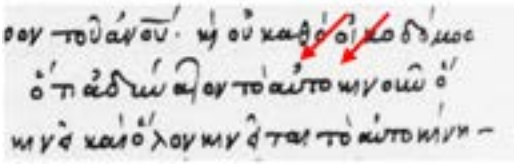

Fig. 32. Paris, Bibliothèque nationale de France, Grec 1947, f. 197r.

384,9-10 τὸ μὲν τὸ ὑπ᾽ ἄλλου κινεῖσθαι, τὸ δὲ τῷ κινεῖσθαι παρ᾽ ἑαυτοῦ Benakis, MSS **B**, **C**: τὸ μὲν τῷ ὑπ᾽ ἄλλου κινεῖσθαι, τὸ δὲ τῷ κινεῖσθαι παρ᾽ ἑαυτοῦ MS **L***. MS **L**'s text, suggested by Logion, is again superior. Cf. Ar. *Phys.* 256a.4-8 Τοῦτο δὲ διχῶς· [...] οὗτος δ᾽ οὐκέτι τῷ ὑπ᾽ ἄλλου κινεῖσθαι.

MS **L** f. 136r:

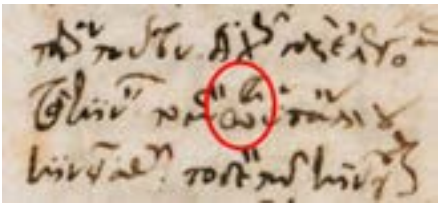

Fig. 33. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 136r.

MS **B** f. 126r:

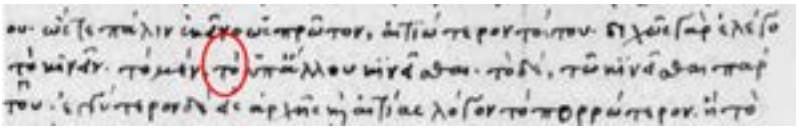

Fig. 34. Paris, Bibliothèque nationale de France, Grec 1920, f. 126r.

MS **C** f. 198r:

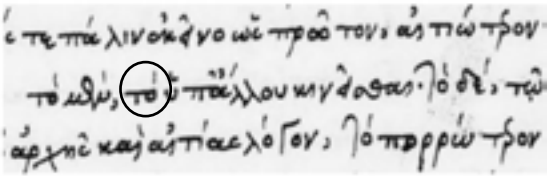

Fig. 35. Paris, Bibliothèque nationale de France, Grec 1947, f. 198r.

398, 5 τοῦτο ὑφ᾽ ἑνὸς ἑκάστου συμβαίνει Benakis, MSS **B**, **C**: ἐφ᾽ ἑνὸς ἑκάστου MS **L***, suggested by Logion. Only ἐφ᾽ ἑνὸς can be correct.

MS **L** f. 141r:

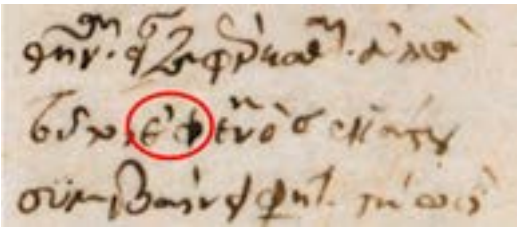

Fig. 36. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 141r.

MS **B** f. 191r:

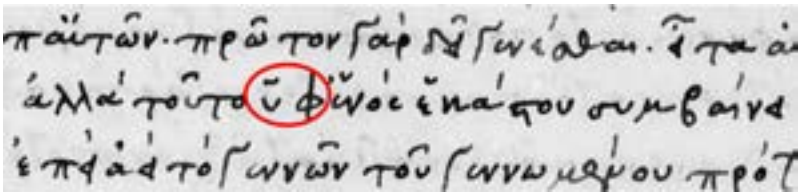

Fig. 37. Paris, Bibliothèque nationale de France, Grec 1920, f. 191r.

MS **C** f. 202v:

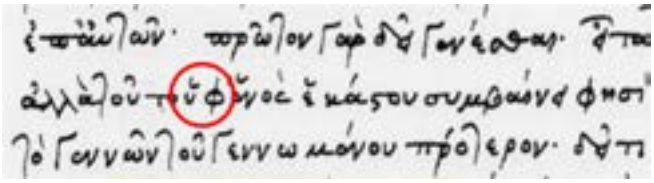

Fig. 38. Paris, Bibliothèque nationale de France, Grec 1947, f. 202v.

408,20 ἁπλῶς δὴ οὐ Benakis, MSS **B**, **C**: ἁπλῶς δὲ οὔ [*sic*] MS **L***, suggested by Logion. ἁπλῶς δὴ οὐ is unparalleled in Greek literature. By contrast, ἁπλῶς δὲ οὔ is not just good Aristotelian idiom but also occurs in the base text of Aristotle's *Physics* (263b7), on the same folio page of MS **L** (f. 145v) as the comment in question (red circles, commentary on the left, base text on the right):

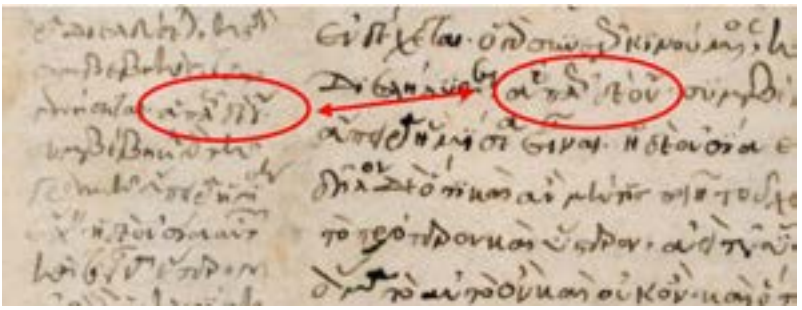

Fig. 39. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 145v.

410,17 ἐν αὐτῷ γὰρ τῷ χρόνῳ, ἐν ᾧ γίνεταί τις Benakis, MSS **B**, **C**: τι MS **L*** after correction, suggested by Logion. τι is right. Note τις (blue circle) in the line immediately above τι (red circle) in MS **L** f. 146r:

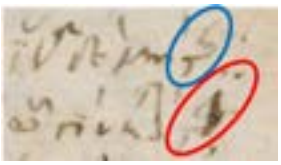

Fig. 40. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 146r.

Logion, we can conclude, shows a pronounced tendency toward siding with MS **L** against Benakis and the control manuscripts **B** and **C**. In fact, even where the machine goes wrong it still helps to reassess MS **L**'s role in the transmission of the Aristotle commentary. I end this chapter by considering a selection of passages where, without agreeing with MS **L**, Logion nonetheless prompts reflection on its value as a witness:

25,9-10 τὰ δ' ἀπογεννάματα αἰσθήσει καὶ δόξᾳ Benakis: δόξα MSS **B**, **C**: δόξᾳ [*sic*] MS **L***. Logion suggests δόξῃ. The Doric dative is embedded in a quote from Timaeus, so Benakis is right to print it. Logon overcorrects to the Attic dative in eta. While the conjecture itself must be rejected, it draws attention to the fact that MS **L** does in fact spell a true dative by inserting iota subscript, contrary to normal Byzantine practice (f. 6r):

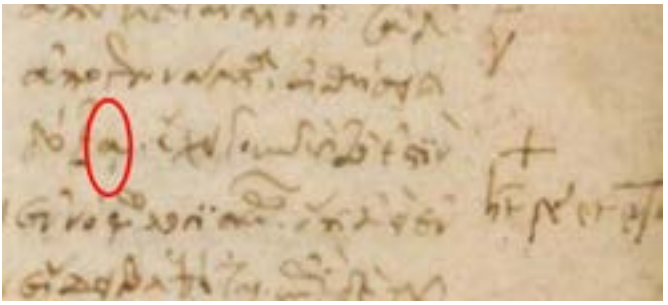

Fig. 41. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 6r.

The control manuscripts **B** and **C** both spell without iota subscript. Cf. MS **B** f. 8r:

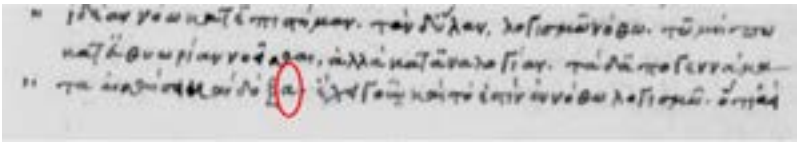

Fig. 42. Paris, Bibliothèque nationale de France, Grec 1920, f. 8r.

And MS **C** f. 94r:

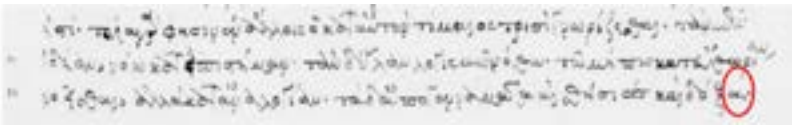

Fig. 43. Paris, Bibliothèque nationale de France, Grec 1947, f. 94r.

89,12 ἄλλο τε κομισόμενος Benakis. Benakis reports ἄλλο τε (two words) for MS **L** (and **D**, "non vidi"). In fact, MS **L*** should be read ἄλλοτε (one word), which is plainly what the author intended. Logion suggests the incorrect ἄλλο τι but deserves credit for flagging the problem with Benakis' text. MSS **A** ("non vidi"), **B**, and **C** have the inferior ἄλλο τὸ κομισόμενον (*sic*).

MS **L** f. 27r:

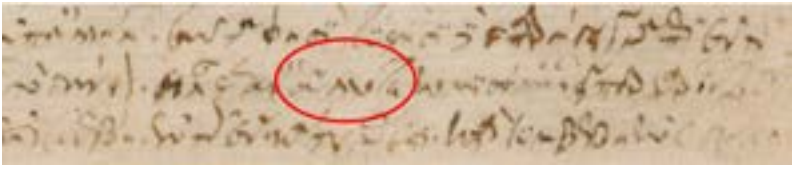

Fig. 44. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 27r.

194,4 ἀλλὰ οἷον τὸ ἓν τοιοῦτον καὶ θάτερον Benakis, MSS **B**, **C**, **L**. Logion suggests ἀλλ' οἷον. As Concetta Luna points out to me, ἀλλὰ οἷον with hiatus is possible in principle (it is printed by editors in e.g., Plato, *Leg.* 832 B 5; Plotin, *Enn.* II 5, 5.8 and often; Themistius, *Or.* 2: I, 44.7 Downey; Hermias, *In Phaedr.* 206.18 Lucarini-Moreschini; Damascius, *In Phaed.* I, § 290.2 Westerink; Philoponus, *In De gen. et corr.* 109.6 Vitelli; id., *In Phys.* 721.9 Vitelli, etc.). However, Psellos and Pachymeres appear to use only elided ἀλλ' οἷον (38 times and 10 times respectively) and alpha is also elided the only other time the phrase occurs in our Aristotle commentary (179,20 Benakis). In the present case, the layout of MS **L** may have encouraged the unusual spelling with hiatus by placing line break between the two words (f. 63v):

Fig. 45. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 63v.

Detail of previous image (with ἀλλὰ at line end circled in red):

Fig. 46. Detail of previous image (with ἀλλὰ at line end circled in red) – Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 63v.

279,22 ἀδιαίρετα ἢ πᾶσα κίνησις Benakis, MSS **B**, **C**: ἀδιαίρετα, ἡ πᾶσα κίνησις MS **L***. Logion suggests ἀδιαίρετα πᾶσα κίνησις. Logion's conjecture is wrong but prompts a reassessment of the transmission which shows that MS **L** alone preserves the correct text (f. 91r):

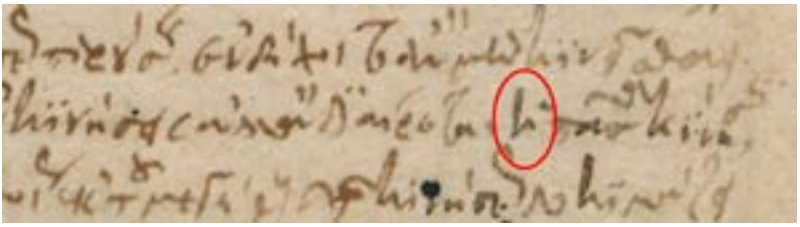

Fig. 47. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 91r.

370,25 ὅτε λίθος Benakis: ὅ, τε [*sic*, with comma indicating word boundary] MSS **B***, **C***, **L***. Logion flags ὅτε without offering the correct solution. ὅ, τε echoes MS **L**'s base text of the *Physics* (ὅ, τε λίθος again at 253b30, see below), against modern editors who print ὁ δὲ λίθος.

MS **L** f. 130v (red arrow points to comma before τε, blue arrow to breathing above ἐν):

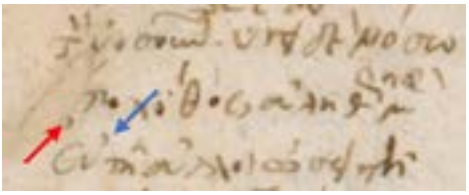

Fig. 48. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 130v.

MS **B** f. 121r:

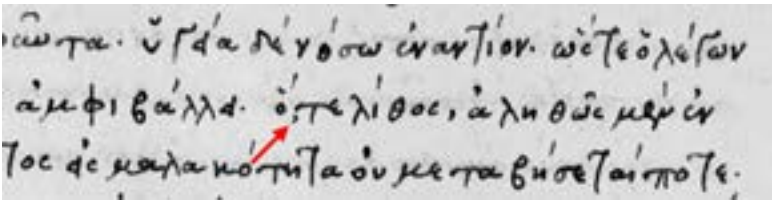

Fig. 49. Paris, Bibliothèque nationale de France, Grec 1920, f. 121r.

MS **C** f. 193v:

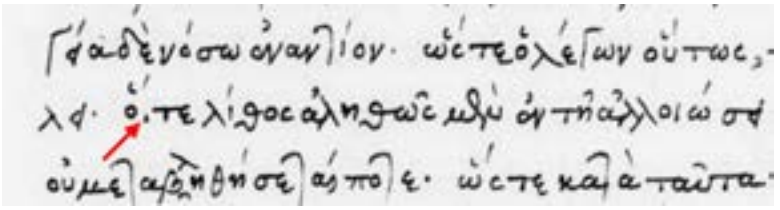

Fig. 50. Paris, Bibliothèque nationale de France, Grec 1947, f. 193v.

Compare the Aristotelian base text as written in MS **L** (f. 130v):

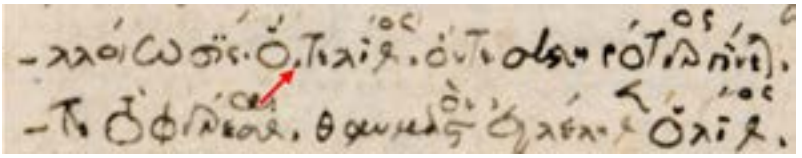

Fig. 51. Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5, f. 130v.

Summarizing the final part of the discussion, even where Logion does not side with MS **L**, it can prompt a reassessment of its value, be that by stimulating reflection on its layout; by suggesting further connections between the commentary and the Aristotelian base text; or simply by inviting us to revisit passages that previous scholars misread or arguably misjudged. For now, these are preliminary conclusions: more work is needed to establish just how important MS **L** is in the transmission of the Aristotle commentary; and how strong the philological case is for considering it an author copy. I will anticipate here that, in my view, the philological arguments presented above can be added to Golitsis' codicological considerations and thus support his conclusion that the commentary was authored, and not just copied, by Pachymeres.[38] What bears emphasizing for the purposes of this chapter is the role Logion plays in drawing attention to questions about manuscript reliability and attribution, so that human scholars can then attempt to answer them.

[38] Most compelling, it seems to me, is a passage in 332,21-333,3 Benakis where Pachymeres makes extensive corrections to his own text.

Conclusion

Machine learning algorithms, I have argued, are more than just interesting gadgets. Among their several other philological uses illustrated in this volume, they can help draw attention to human biases in the assessment of individual manuscript readings and, indeed, whole manuscripts. In my first example, the machine suggested modifying and merging two words that look, on the face of it, perfectly unobjectionable. Human beings think grammatically and by and large that is a good thing. Grammar helps us recognize linguistic patterns and guard against the kind of nonsense that machine learning algorithms often produce. But grammatical intuition can become a hindrance. The problem is not so much that *we* know Greek too well for our own good but that the medieval scribes did: they tended to err in ways that made sense to them. A nonsensical reading would be much easier to detect and restore to the original wording than the errors they tended to produce. If the scribe of MS **O** had written εἴπιμι instead of εἴποι μοι, the error would have been discovered long ago. εἴποι μοι looks legitimately grammatical, which makes it hard for human readers to question without somebody or something prompting them to do so. Artificial intelligence can prompt us to reconsider the transmitted text in precisely this way. I could have adduced many other examples of this kind, but the point of this piece is to illustrate by selection, rather than provide the kind of coverage and statistical assessment that chapter 5, in particular, aims to provide.

My second and third examples dealt with philological expertise, and specifically the judgments that editors form of the manuscript witnesses on which they base their texts. To judge a manuscript 'excellent' or 'poor' is of course legitimate. The problems begin when generalizations of this kind unduly influence specific editorial decisions, which can only be based on the merits of each individual case, as I tried to show by way of my second example. Logion, which knows nothing about manuscripts, can for that very reason remind us that following what we consider the 'best' witness may not always produce the most reliable text. My third example went further, suggesting that Logion can help with assessing entire manuscripts and even, as I plan to argue in greater detail elsewhere, with authorship attribution. I anticipate here that Pachymeres himself did in fact author the commentary on Aristotle's *Physics* which he wrote down in MS **L**. But whether or not we believe this to be true, we must take care not to let that question distract us from the task of recording the readings in that manuscript

accurately and evaluating them as objectively as possible. The point here is not at all that machines produce better or more objective philological work than humans. Machines too are biased, as we read daily in the news and as illustrated in chapter one. My point here is that machines can differ, in their biases, from humans – and that, I argued, is one reason why machine learning can provide useful tools for philological work.

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Johannes Haubold

Part II

An Experiment in Artificial Intelligence and Greek Philology

4. How Does Logion Work? An Introduction for Philologists

Logion is the first deep neural network designed to assist philologists in editing premodern Greek texts that have reached us via manuscript transmission. This chapter introduces the model and describes how it works. The aim is to provide, in clear and non-technical language, the main information philologists need in order to engage with Logion knowledgeably. We explain how language models like Logion learn; how they process text; and how they can be used to identify and emend cases of corruption in the transmission of premodern texts. Important terms and concepts, such as tokenization, Levenshtein distance, and chance/confidence ratio, are introduced in the course of our account. A separate appendix explains gradient descent, the method by which Logion learns.

Keywords: Masked Language Modeling; Subword Tokenization; BERT; Gradient Descent; Chance-confidence Ratio; Ancient Greek; Premodern Greek

In this introductory chapter, we aim to provide guidance about language models for philologists interested in machine learning methods for the restoration of ancient texts. More specifically, in the spirit of interdisciplinary collaboration, the point of this contribution is to support an intuitive understanding of how Logion is trained. The account offered here is by no means intended to be exhaustive or even sufficient for a reader interested in the workings of language models. It is, rather, a response to questions we were frequently asked by our philological collaborators, which is to say, the other contributors to this volume, who in turn graciously introduced us to important principles and practices in philology.

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How Do Language Models Learn?

Natural language processing (NLP) has an extensive history prior to the arrival of the large models we know today, such as ChatGPT. Even before the advent of deep learning, researchers have battled with the question: what are the most effective ways to teach artificial systems to understand and generate language?

Consider the ways in which humans teach other humans to learn natural languages, both as infants hearing words for the first time, and as students systematically learning foreign languages. In the latter scenario, teachers lay out rules of grammar, compile lists of vocabulary, and design tests to assess their students' mastery. In the former, infants learn without systematic instruction of grammar, lists of vocabulary, or formal assessments, gradually discerning patterns and meaning. Nevertheless, they are apparently able to learn from observations of the language around them, and the hope is that the same can be made true for artificial systems.[1] At the moment, artificial systems need access to large quantities of linguistic data in order to learn.

In the age of the internet, large corpora are easy to acquire, with trillions of words available across sites such as Twitter, Reddit, and Wikipedia.[2] Admittedly, access to training data is significantly more limited for premodern and minority languages, but provided we have datasets on the order of millions of words, it is still feasible to apply machine learning methods to support philological aims.

The exact mechanisms for training models differ, but the training objective traditionally involves taking text from a corpus, hiding some of the text, and tasking the model with guessing the missing contents. One such mechanism is the Masked Language Modeling (MLM) objective, which typically 'masks out' 15% of an input text. The model is then asked to fill in the missing text, using the provided context.[3] This

[1] For a survey on the relationship between language acquisition in infants and in LLMs, see Vong et al. 2024, Lake et al. 2023.

[2] One such open-source corpus, RedPajama-Data, contains roughly one trillion words taken from Commoncrawl, C4, GitHub, ArXiv, Wikipedia, and StackExchange (Together Computer 2023).

[3] Another pre-training objective employed by most modern large language models involves predicting text given only prior context, rather than bidirectional context (Radford et al. 2018). As only prior context is required, it is straightforward to use such (autoregressive) models to generate streams of text.

is the training objective used by BERT, which is the model we employ for Logion.[4]

Consider, for example, the following (masked) sentence: I am [MASK] to the store to buy cherries for a [MASK]. Which words could feasibly fill the masks? Someone could be 'going', 'heading', or 'driving' to the store to buy cherries for a 'snack', a 'friend', or even a 'change' (maybe they've grown bored of apples). These are all reasonable suggestions, but in the end, we might reveal that the masked words were 'running' and 'picnic'. Depending on the corpus from which we are drawing examples, another masked sentence might read: The Leaning Tower stands in the city of [MASK]. In this case, there may be fewer reasonable guesses than in our previous example and a different knowledge base required to form them.

Here we begin to observe the power of MLM as a means of training a language model: there is no need to prepare specialized lessons in order to train such a model. It is only necessary to take text from a desired corpus, which serves as our ground-truth data, and to mask portions of it, then ask the model to attempt to fill the masked portions of text. Conveniently, we retain the 'answer key' in the form of the original, unmasked text. The model attempts to fill the masked portions of text, then compares its guesses with the original text. By repeating the process of masking, having the model guess at what is missing, then learning from its errors and successes, the model eventually learns to produce better guesses. Without receiving specific instruction, it gains what we would call a command of grammar, vocabulary, contextual sensitivity, and world knowledge. Although MLM requires only a sufficient quantity of raw data, it holds the potential to impart advanced capacity to interpret and generate language.

It is worth noting the similarity between the random segments of text removed in MLM and those lost to physical manuscript damage, which result in lacunae. Logion trains on texts that look roughly like this:

Τοιοῦτός ἐστι ἀληθῶς [MASK] ἀγαθὸς ἄνθρωπος [MASK] δὴ ἑαυτὸν ἐχαρακτήρισας ἐν [MASK] πρὸς ἡμᾶς [MASK], ὁσιώτατε δέσποτα, [MASK] ἐκ τῶν [MASK] τὴν φιλίαν τεκμηριώσας, [MASK] ἀπὸ τῆς [MASK] φύσεως. [MASK] μὲν γὰρ πρὸς [MASK] φιλεῖν καὶ τὸ [MASK] τὴς φιλίας μέτρον ὁ [MASK] δύναται, [MASK] καὶ τοῦτο [MASK] αὐτόν, οἷς φιλεῖν [MASK] εἰ δὲ τὸ μὲν [MASK] ἀναβλαστάνει φύσεως . . .

[4] Devlin et al. 2019.

Just as philologists attempt to fill lacunae, so Logion seeks to fill millions of masks, randomly strewn throughout the training corpus. In this way, by the end of its training, the language model itself will have become a philologist of sorts, with a discerning sense of probable and improbable conjectures when it comes to proposing a restoration. The philological task of filling in corrupt or lacunose portions of text is closely related to Logion's training objective.

How Do Language Models Learn From Their Mistakes?

We have discussed how Logion predicts missing words by making guesses based on surrounding context, and how it then learns from its failures and successes at filling masked portions of text, performing a large number of reiterations of the process, until the guesses become more accurate, but without ever needing specialized linguistic lessons. In machine learning, the mechanisms used for predicting masked portions of text are termed 'weights'. Using weights to make predictions amounts to performing a simple sequence of deterministic arithmetic operations; the challenge is settling on an intelligent set of weights to perform a given task (and this is the very crux of any machine learning research).

Gradient descent is a method the model uses to improve its guesses, produced by its set of weights, over time. After making guesses with an initial set of random weights, the model receives feedback on its guesses (in the form of ground truth text, i.e. unmasking the masked portions), and then uses this feedback to refine its choice of weights. Initially, the model will make many errors. However, each training example imparts greater mastery of premodern Greek, in the case of Logion, and after many iterations, the model can discover weights which drastically reduce errors in its predictions. The point here is to arrive at accurate enough predictions that they can be useful for supporting philological work.

The process by which the model learns may be illustrated as follows. Suppose you are learning to throw darts. Each time you throw a dart and miss the bullseye, you adjust your aim based on how far off you were. If you throw too far to the left, you aim a bit more to the right on your next throw, and vice versa. Gradient descent operates in a similar spirit; it gradually adjusts its 'aim' (i.e., its weights) based on past errors, in an effort to get closer to the 'bullseye' (i.e., the ground truth) on subsequent attempts. By continuously hurling darts and adjusting

trajectories, the model learns the contextual patterns of words in premodern Greek, gradually improving its ability to understand and predict missing bits of text.

The dartboard analogy offers a simplified glimpse of the iterative process of predicting missing words and refining those predictions over time, but in one crucial respect the analogy is flawed. In dart throwing, the objective never moves: you throw the same dart to hit the same bullseye each time. In contrast, when Logion predicts a missing word, the context changes with each guess, meaning the weights must be suited to handle a vast set of contexts.

Accordingly, we need to imagine that each dart differs in heft and balance, each dartboard changes in size and distance, and the weather conditions are unforgivingly volatile. A skilled dart player must gain a general intuition over the arena of variables to have even a hope of hitting the bullseye. Competence in unfamiliar contexts is the precise challenge faced by Logion. Its predictive 'throwing technique' must adapt based on the characteristics of each unique context. While the specific computational mechanisms that define weights are complex, they are designed to be highly adaptable, allowing Logion accurately to predict missing words in premodern Greek contexts in general. For a deeper dive into the mathematical underpinnings of weights, we refer the interested reader to more specialized literature on the subject.[5] For the specific parameters used for training Logion, we refer the reader to the authors' technical publications.[6]

Gradient descent can be further illustrated by another analogy. Consider the task of descending into a valley with no clear path and a thick fog obstructing visibility beyond one or two steps. You cannot see the bottom of the valley, nor the best path to get there, but you can see in which direction a few steps would yield an incremental decrease in altitude.

The strategy of the hiker is therefore to 'descend' along the 'gradient' (or slope) of the mountain. This is, by analogy, similar to the procedure of gradient descent used to find 'good weights' in Logion. At some point, the hiker reaches a point at which taking steps in any direction would lead to climbing up another slope. At that point, the descent has been completed. For Logion, weights are adjusted until predictions no longer improve in accuracy, and moving in any direction would spoil

[5] Goodfellow et al. 2016.

[6] Cowen-Breen et al. 2023a.

performance. Just as the hiker trusts the landscape to guide the climb down to the valley, Logion relies on gradient descent to navigate the vast search space of possible weights, steadily moving toward a good solution.

How Do Language Models Process Text? What Is Tokenization?

So far, we have approached the concept of 'masking' as though it were applied at a word-level granularity, which is not entirely precise (or even feasible). With inflected languages in particular, the number of possible 'words' quickly multiplies when accounting for the variety of forms each word can assume. In the corpus of premodern Greek texts, which we used to train and evaluate our models, we count nearly three million unique word forms. Treating each of these forms as a unique entity would make learning their contextual uses exceedingly difficult. In practice, we take the standard approach of breaking down text into shorter strings of text, or 'tokens', which allows the model to derive meaning from shared components of words, rather than treating each word as an isolated unit.[7]

Although at present tokenization (i.e. the division of premodern Greek into short strings of text) is done on statistical rather than grammatical principles, it still has obvious benefits for text prediction. Take, for example, the words ἵππος and ἵππων. By breaking them down into the sub-word tokens ἵππ-ος and ἵππ-ων, we allow the model to learn about the shared lemma ἵππ in both contexts. A consequence of sub-word tokenization is that it gives the model the potential to make sense of words which it has never seen before. Even if the word ἀφηγησόμεθα never appeared in training, the model might have seen the tokens ἀφηγησ- and -όμεθα from other word forms, and thus can reason about how they might interact with each other. Another benefit of sub-word tokenization is that it dramatically reduces vocabulary size. We can choose an arbitrary number of sub-word tokens, into which any text can be broken down (in the worst case, a word can always be broken down into a string of single characters). In our case, we define a set of fifty thousand sub-word tokens, reducing the field of

[7] Common sub-word tokenization methods include Byte-Pair Encoding (Sennrich et al. 2016), Unigram (Kudo 2018), and WordPiece tokenization (Schuster and Nakajima 2012), the last of which we employ for Logion.

options down from three million for the task of predicting masked tokens.[8] It is worth noting that the process of selecting a set of sub-word tokens is an active area of research.[9] Tokenizations are typically chosen statistically, rather than through grammatical principles, which would identify, for example, roots and endings, ἵππ-ος and ἵππ-ων. Future interdisciplinary work could explore whether morphological knowledge could assist in designing tokenization schemes which improve model performance for philological tasks.

Training Logion, then, roughly amounts to the following procedure: 1. Gather a large corpus of premodern Greek; 2. convert the text into sequences of sub-word tokens; 3. replace a randomly selected 15% of tokens with masks; 4. attempt to predict the masked tokens; 5. compare these predictions with the actual words and adjust the model's settings accordingly, using gradient descent.

How Can This Model Be Used to Detect Errors in Textual Transmission?

Up to now, we have described how Logion is trained to fill in missing text in a given context. However, as a byproduct of learning to predict what is likely, the model also learns to evaluate what is improbable. To be more precise, when a portion of text is replaced with a mask, the model does not just predict a single replacement; instead, it estimates the likelihood of each of some 50,000 possibilities (or 'tokens', as we explained above). Consider this input: "The goal of life is [MASK]". A model trained on English text might output:

survival: 23%
love: 12%
freedom: 4%
toothbrush: 0.01%

[8] For the original BERT model, Devlin et al. 2019 chose a vocabulary size of 35,000 tokens. More recent large language models, with significantly more parameters and training data, such as Llama-3. (https://ai.meta.com/blog/meta-llama-3/) and Mistral (https://docs.mistral.ai/guides/tokenization/), use over 128,000 tokens. We increased the vocabulary size to 50,000 tokens after observing performance gains over a model trained with 35,000 tokens.

[9] Recent investigations and formalizations include Zouhar et al. 2023, Schmidt et al. 2024, Gastaldi et al. 2024, among many others.

and so on. In the case of Logion, the list is fifty thousand tokens long (each word being made up of a varying number of tokens). Notably, most tokens should be assigned a vanishingly small probability. For any given context, only a few different possibilities will serve as plausible predictions. Nonetheless, for any given mask, we have access to the probability which the model assigns to 50,000 tokens.

With these probability distributions, we detect errors by computing a quantity we call the *chance-confidence ratio* (CCR) for each token in a corpus, ranking all tokens by their respective CCR, and passing along the ranked list to philologists for review.[10] In theory, tokens with higher CCRs are more likely to be errors.

What Is the Chance-Confidence Ratio?

CCR computes how much more likely the model's top suggestion is than what is actually transmitted. Formally, 'chance' is defined as the model-evaluated probability of the transmitted token given its context. 'Confidence' is defined as the model-evaluated probability of the top model-suggested replacement for the transmitted token given the same context. The CCR is calculated by dividing the confidence value by the chance value, and it enjoys the theoretical property that the token with the highest CCR value is provably equivalent to the location at which a one-token change in the transmitted text would result in the greatest increase in model-evaluated corpus likelihood.

As an example, consider the following text: "The quick brown fox bumps over the lazy dog". To calculate the CCR for 'bumps' in the given context, we replace it with a mask token and analyze the model's output: "The quick brown fox [MASK] over the lazy dog". Examining the list of fifty thousand tokens and their assigned likelihoods, we check what probability the model assigns to 'bumps' – say 0.2% (depending of course on the training data); this is the value we assign to 'chance'. We then see what token was assigned the highest likelihood by the model – let us say this is the token 'jumps', with a probability of 20%; this is the value we assign to 'confidence'. Now, we compute 20% / 0.2% = 100, and this is the CCR value for the token 'bumps' in the given context.

In practice, to perform error detection on a given corpus, we calcu-

[10] Cowen-Breen et al. 2023a.

late the CCR of every token in that corpus. We rank the tokens in order of highest CCR and, crucially, we exclude any cases where the model's top suggested replacement is too different from the original word. The distance between transmitted text and suggested emendation is measured by a metric named after the Soviet mathematician Vladimir Levenshtein. When applied to language, Levenshtein distance refers to the minimum number of single-character edits required to change one word into another. For our work, the Levenshtein distance expresses our tolerance for the difference between a proposed emendation and the transmitted text. For example, if the model suggests replacing the token γε with ἐλέφαντας, such a suggestion differs drastically from the original. Even in the hypothetical case that the model assigned it high probability, setting a low Levenshtein distance would eliminate such a suggestion. Replacing γε with δέ would, by contrast, survive as a suggestion even if we restricted model outputs to a Levenshtein distance of just one, in that the two words differ by a single letter. So far, we have produced error reports which consider a Levenshtein distance of one, two, and three, asking experts to assess the usefulness of each report: chapter six, in particular, focuses on how results differ as we vary the Levenshtein distance. We should also say that at present accents are not taken into account by our model.

Assuming that a language model can accurately predict the likelihood of specific tokens appearing in various contexts, the use of CCR combined with Levenshtein distance puts error detection at our fingertips. That said, even for LLMs trained on English which have training data and model parameters orders of magnitude higher than what is feasible in the settings of premodern or minority languages, pushing the limits of model performance towards human, let alone superhuman, abilities remains far from attainable for many tasks.[11] Especially in our lower-resource setting, close communication between researchers with expertise in philology and colleagues who specialize in machine learning is of the utmost importance. The work within this volume exemplifies the kind of interdisciplinary collaboration needed, in our view, at this stage of research.

[11] E.g., for software engineering (Jimenez et al. 2023), computer programming (Shi et al. 2024), solving mathematic Olympiad problems (Trinh et al. 2024).

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5. How to Work with a Logion Report

This chapter focuses on one use of Logion in particular: the model can be asked to identify textual corruptions. Specifically, it flags passages that contain unlikely strings of text (low chance that such strings should occur where they do) in combination with their capacity to become very likely strings of text by way of small-scale editorial interventions (high machine confidence in proposed emendation). We analyze the first 500 flags in a chance-confidence report where the model is restricted to the smallest possible intervention, i.e. an emendation by one letter only (a Levenshtein Distance 1 report). The aim of our analysis is threefold: first, we want to give a sense of Logion's performance not by selecting impressive examples, but by analyzing an entire report and compiling accurate statistics of machine success at identifying textual corruptions and emending them. Second, we show how to use a Logion report in practice, with the aim of providing a guide for other users. Third, we offer feedback on machine performance, in order to guide further technological development of Logion, arguing that machine failures deserve as much attention as successes.

Keywords: Logion Flag; Logion Report; Machine Performance; ρ Value; Statistical Analysis; Ancient Greek; Premodern Greek

In this chapter we illustrate how working with Logion to emend the text of Michael Psellos is an interactive and collaborative process. Here we focus on one feature of Logion in particular: the model can be asked to identify textual corruptions. Specifically, as explained in chapter four, it flags passages that contain unlikely strings of text, which however become likely after small-scale editorial interventions (in the language of our model developers, we focus on 'low chance' that such strings should occur where they do, combined with 'high confidence' in the proposed emendation). In this chapter we analyze the first 500

Li, Y., Haubold, J. 2025. "How to Work with a Logion Report" in Battezzato, L., Graziosi, B., and Haubold, J. eds. *Artificial Intelligence and Greek Philology: An Experiment*, Pisa: 109-133.

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flags in a chance-confidence report where the model is restricted to the smallest possible intervention, i.e. an emendation by one letter only (Levenshtein Distance 1, henceforth LD1).

The aim of our analysis is threefold: first, we want to give a sense of Logion's performance not by selecting impressive examples, but by analyzing an entire report and compiling accurate statistics of machine success at identifying textual corruptions and emending them. This is important: success in textual criticism focuses on brilliant examples of the practice, but, as explained in chapter one, success in machine learning is a matter of statistics. Second, we show how best to use a Logion report in practice, so as to support machine learning as well as Greek philology. Third, we offer feedback on machine performance, in order to guide further development of Logion, arguing that machine failures deserve at least as much attention as successes.

1. *What Is a Logion Report?*

A Logion report is produced by dividing the text under analysis – in our case the oeuvre of Michael Psellos – into short paragraphs and asking the model to flag combinations of letters that are unlikely where they are found (low chance), only in cases where those combinations become likely after small-scale editorial interventions (high machine confidence in emendation). Figure 1 shows the first entry in a Logion report.

Fig. 1. Flag 1 in the sample LD1 report generated by Logion.

The flagged word and its proposed replacement are printed at the top of the paragraph in the format A → B, with A being the flagged word and B the suggested alternative. The entire paragraph is color-coded based on how problematic Logion deems each word to be, ranging from green (least problematic) to red (most problematic). The flagged word typically appears in the most intense shade of red.[1] In Figure 1, Logion flags αδριαντοποιητικη (*sic*) and correctly proposes in its stead ανδριαντοποιητικη.[2] The specific flags generated by Logion and the alternative readings it proposes depend on the Levenshtein distance (LD) set for each report. LD (typically set to one, two, or three) measures the difference between a flagged word and its replacement. In the sample report considered here, LD is set to one, allowing Logion to make edits involving only a single character, such as adding, deleting, or substituting a letter. Three examples from LD1 illustrate how Logion performs these editorial actions:

> Flag 1 (*In Ar. phys.* 79,5 Benakis): the difference between αδριαντοποιητικη and Logion's ανδριαντοποιητικη is an additional *nu* between the first *alpha* and *delta*. This addition is correct.
> Flag 34 (*Ep.* 202.201 Papaioannou): Logion incorrectly suggests deleting word-initial *kappa* in κερω to read ερω.
> Flag 24 (*Laud. in Jo. Crust.* l.268 Gautier): Logion suggests replacing the second *alpha* in αυλαις with an *omicron* to read αυλοις, correctly in our view, see below.

Two sets of numerical values quantify Logion's decision to flag words as suspicious and propose emendations. First, the likelihood of the flagged word appearing in its context is given in the top right-hand corner, following the format A → B, where A represents the

[1] As a rule, Logion creates a separate flag for every word it deems problematic, so although there may be more than one red word within one paragraph, they each receive their own flag. For example, the paragraph containing Flag 1 also contains another word, προκειται, which is deemed problematic and receives its own flag (no. 56 in the same report), complete with a good suggestion for how to emend it (πρόσκειται, the transmitted reading which is misreported in the critical edition of the text).

[2] For technical reasons, Logion works without diacritical signs of any kind, including accents, breathings, and markers of diaeresis or crasis. Also excluded is iota subscript. More on how this affects its performance below: 124-5.

chance of occurrence of the suspected word and B indicates Logion's confidence in the suggested alternative. For example, in Flag 1, the chance of αδριαντοποιητικη occurring in its given context is 2.12×10^{-10}, which is extremely low. This comes as no surprise to philologists because the word is not attested in Greek. In contrast, Logion's confidence in the suggested alternative, ανδριαντοποιητικη, is 0.055 (= 5.5% as shown on the report), which is much higher than the chance of αδριαντοποιητικη being correct.

These two numbers contribute to the calculation of the ρ value, which is printed at the end of each flag. Representing the chance-confidence ratio, ρ represents Logion's confidence in its own suggestion divided by the chance of the suspected word being correct.[3] The ρ value shows the relative certainty of flagging and emending as calculated by the model; the greater its value, the more certain Logion is about its emendation. In the example above, the ρ value is 261,144,333, which is extremely high. It is important to note, however, that a high ρ value does not guarantee the correctness of a flag. Each flag should be evaluated on a case-by-case basis, with careful consideration given to grammar, syntax, style, wider context, transmission, possible sources, and reasons why the texts may have been corrupted. As with any emendation that may occur to a human being, a proposal for emendation needs to be backed by argument and Logion provides no justification beyond the numbers presented in the report.

The ρ number not only indicates machine confidence but also serves as a convenient ordering device for Logion reports, as flags are arranged in descending order of ρ values. How this affects the overall shape of a report is something we discuss later in this chapter. As noted in the introduction to this volume, the base text of Psellos is sourced from the Thesaurus Linguae Graecae (TLG), by permission of its director, to whom we are very grateful. Diacritics, iota subscripts, line numbers, section/chapter numbers, page break marks, and, occasionally, other editorial marks are removed prior to training. Then, the corpus is divided into paragraph-sized chunks based on specific rules: each paragraph must begin and end with syntactically complete sentences, come from a single work, and have a manageable length of no more than five hundred and twelve tokens.[4] This process ensures that each paragraph provided to Logion for training and report generation is a

[3] For further details see Brooks and Cowen-Breen, chapter 4 in this volume.

[4] For tokens and our method of tokenization, see Brooks and Cowen-Breen, this volume: 102-3.

freestanding, reasonably substantial portion of text that contains only unmarked words and punctuation, as in the paragraph in Figure 1. However, inadequately cleaned paragraphs may still contain extraneous marks, which Logion may mistake for letters or punctuation and flag as suspicious as a result.[5]

Before a report can be generated, preparatory work continues with training the model. For the work presented in this volume, the digitized oeuvre of Psellos was randomly divided into five segments of similar length. Then, four sets of texts, constituting roughly 80% of the overall data, were used to train Logion, while the remaining set, constituting roughly 20% of the data and never used in training, formed the basis for our error detection experiment. This process was repeated for the remaining four segments, with LD initially set to one, and was then repeated with LD set to two and three respectively.[6] Each round of report generation thus yielded a total of fifteen distinctive reports (five each for LD one, two, and three), with each report representative of Logion's performance at the corresponding LD due to the random selection of training and testing data.[7]

2. *A Typology of Machine-Generated Results*

The first step, with any given flag in a report, is to identify the passage that contains the flag with the help of TLG, where the text is available with diacritics and other editorial mark-up. This step, currently performed manually, will be automated, we hope, in the near future. We also hope that, in future, artificial intelligence will provide useful support for accurate translation. For now, the most urgent task is to work with Logion in such a way as to publish philologically significant results and provide machine-actionable feedback on model perfor-

[5] For further discussion of this type of flag see below: 115.

[6] Reports at Levenshtein distances higher than 3 have not been found to be effective.

[7] The reports generated by the method described above, including the sample LD1 report analyzed in this chapter, are known as 'unconsolidated' reports. Flags can be further consolidated by combining the five hundred highest ρ numbers from all five unconsolidated reports into one single 'consolidated' report, representing Logion's strongest flags at any given Levenshtein distance according to its computation of the chance-confidence ratio. However, since ρ numbers are not always indicative of the accuracy of individual flags and many philologically important flags may occur further down a report (see below: 122-3), we opted to use an unconsolidated report for our analysis in this chapter.

mance. For this latter task, it is important to categorize results, in full awareness that philology is, in the words of Sheldon Pollock, a 'soft science', involving subjective judgement.[8] Nevertheless, it is important for philologists to assess machine-generated results in such a way that their assessments can contribute to machine learning as well as Greek philology. It is in this spirit that we set out the categories we used for a statistical evaluation of a sample LD1 report.

After analyzing the flagged passage in its original context, the user of Logion evaluates whether 1) Logion has correctly flagged the word and/or its context as suspicious, and whether 2) Logion's proposed emendation is convincing. To facilitate quantitative analysis and streamline the process, we propose six basic categories of flags, each illustrated by an example.

1. Logion is judged to have correctly flagged a suspicious word in the text and suggested a convincing emendation. We call this type of flag '**good flag, good suggestion**'.

   Example. Flag 1 (*In Ar. phys.* 79,5 Benakis): αδριαντοποιητικη (*sic*) → ανδριαντοποιητικη.
   The textual problem is accurately identified and Logion's suggestion is the correct reading.

2. Logion is judged to have correctly flagged a word, but its suggestion is unsatisfactory. We call this type of flag '**good flag, bad suggestion**'.

   Example. Flag 12 (*Chron.* 6.85.12 Renauld): αντην → αυτην.
   While ἄντην, a modern conjecture adopted by Renauld, is indeed suspect, Logion's suggestion αὐτήν is unsatisfactory.[9]

3. A flag falls short of being verifiably correct but still seems plausible. We call this type of flag '**plausible flag**'.

   Example. Flag 18 (*Or. hag.* 3b.328 Fisher): γε → δε.

[8] We refer here to the title of Pollock 2009.

[9] An LD2 report (where Logion is allowed to make a two-letter edit) suggests the more promising αὐτόν, for which see Barnes and Sandri, chapter 6 in this volume, esp. 148-9. They also discuss the more general problem of how to use reports of different Levenshtein distances to best effect.

While Logion's δέ is the manuscript reading, γε is a modern conjecture which may be correct.

4. After careful examination, the quality of Logion's flag remains uncertain. In that case, we record a verdict of '**uncertain flag**'.

   Example. Flag 178 (*Psych*. 122.1 O'Meara): φασιν → φασι.
   Logion's suggestion to delete the movable *nu* in φασίν is difficult to verify without extensive further research on Psellos' treatment of mobile *nu*.

5. The flagged word is judged to be unobjectionable, and Logion has incorrectly suspected it of being corrupt. We call this type of flag '**bad flag**'.

   Example. Flag 19 (*Or. hag*. 1b.271 Fisher): ποτεον → δοτεον.
   ποτέον makes perfect sense in its context. The passage is erroneously flagged, and Logion's suggested reading does not represent an improvement.

6. Logion has flagged extraneous marks that have crept into the text due to insufficient data preparation. We call this type of flag '**bad data**'.[10]

   Example. Flag 23 (*Psych*. 48.30 O'Meara): εγγινο (*sic*) → εγγιν (*sic*).
   This flag arises from insufficient data cleaning. In O'Meara's print edition, the original word ἐγγινομένου spans two pages and appears in TLG as "ἐγγινο- @1 (30) (49) μένου", with the three marks respectively denoting the end of the previous page, line number, and new page number. Preliminary clean-up results in "εγγινο. Μενου", thus creating the non-word εγγινο which Logion flags.

When using a report to emend Psellos' text, it can be helpful to further divide **good flags, good suggestions** into five subcategories. These are outlined below along with illustrative examples.

a. If the TLG text contains an error that is not in the printed edition

[10] This type of flag may still be considered 'good' in the sense that it shows Logion's success in identifying problems created by insufficient data preparation. What matters here is that the result it yields does not constitute an improvement on the text.

on which the digitized text is based, we ascribe the error to the process of **digitization**.

Example. Flag 2 (*Log.* 3.68 Duffy): αω → ανω.
ἄνω is printed in Duffy's edition. The letter *nu* went missing in the process of digitization.

b. If the printed edition contains a form that diverges from the correct manuscript reading and is not possible in Greek, we record it as a **typo** in the **printed edition**.

Example. Flag 16 (*Log.* 28.3 Duffy): μετοπωρα → μετοπωρω.
†μετόπωρα is not Greek. The only manuscript witness transmits correct μετοπώρῳ.[11]

c. If the printed edition contains a form that diverges from the correct manuscript reading and, though possible in principle, is impossible in context, we call the error a **manuscript misreading** in the **printed edition**.

Example. Flag 5 (*In Ar. phys.* 401,1 Benakis): ει → εις.
εἰ is a Greek word, but εἰς is both required by context and correctly transmitted by the manuscripts.

d. If the edition digitized for inclusion in the TLG has adopted an unsatisfactory modern conjecture or an unsatisfactory manuscript reading that is corrected by another edition, we record it as an **editorial error** in the **printed edition**.

Example. Flag 50 (*Chron.* 7.42.5 Renauld): δη → δε.
While δή is a modern conjecture adopted by Émile Renauld, whose edition of the *Chronographia* (Paris 1926–1928) is the basis of the TLG text, Logion's suggestion δέ is the manuscript reading and is rightly adopted by Diether Roderich Reinsch in his more recent edition (Berlin 2014).

e. If the error flagged by Logion is found in the manuscripts, we categorize it as a **scribal error**.

[11] See Barnes and Sandri, chapter 6 in this volume, esp. 139.

> Example. Flag 75 (*Log.* 55.155 Duffy): τοις → ταις.
> The problem flagged by Logion has to do with the noun which the article modifies, μῆνιγξ, -ιγγος, a rare word which is always feminine in Greek. The only manuscript witness transmits τοῖς μήνιξι (*sic*), which shows the scribe's unfamiliarity with this word. Psellos' source text for the passage, Alexander of Aphrodisias' *Problemata* (4.25.2), has ταῖς μήνιγξι. Duffy, in his critical edition, corrects μήνιξι to μήνιγξι but retains τοῖς.[12]

Some flags in Logion can help us identify textual problems in the vicinity of the flagged passage. For example, in *Log.* 55.16 Duffy Logion flags ὃν (the transmitted reading printed by the editor) and proposes ἐν. A comparison with Psellos' source text, Alexander's *Problemata* 3.3.6, shows that following Logion and emending ὃν to ἐν is correct. However, the flagged passage also contains another problem:

τὸ γάλα ψυχρὸν ὃν θερμαίνει, ὅτι αἷμά ἐστι **λελυκωμένον** (*sic*) ὑπ' ἀδένων λευκῶν καὶ ἀναίμων καὶ ἧττον θερμὸν **ὃν** (→ ἐν) τοῖς μαστοῖς μεταβαλλόμενον.

λελυκωμένον is a digitization error in the TLG text and should be corrected to λελευκωμένον. This very basic example gives a first indication of how Logion may help users identify errors beyond what the machine has flagged: the philological scrutiny we devote to a flagged passage will often yield productive results beyond the flagged word itself, especially given the very strict parameters set for LD1 reports.

Not all '**good**' or '**plausible**' flags align neatly with the workflow model proposed here, and *a fortiori* the same is true of flags that are judged to be '**uncertain**'. Some of these pose intricate problems of a philological nature, which are investigated in other contributions to this volume. In Section 4 of this chapter, we focus on flags that are deemed '**bad**' to illustrate patterns in Logion's performance that we hope will assist future users in adjudicating difficult flags. This typology, then, is by no means free of subjective judgement and uncertainty. That said, there are cases where Logion without doubt lets us read manuscripts and understand texts more accurately than has been possible up to now.

[12] A related flag is Flag 86 (*Log.* 55.113 Duffy): τον → την, which modifies μήνιγγα.

3. *Quantifying Machine-Generated Results*

Bearing in mind the categories of flags outlined above, we now offer a quantitative analysis of the top five hundred flags in LD1 (in principle, it would be possible to extend reports beyond such a number, though our analysis suggests this would yield diminishing returns). Our aim here is to illustrate the overall shape of the report and draw attention to distribution patterns.

First, we break down all flags in the report into blocs of fifty and, for each bloc, we count how flags belong, in our view, to each of the six major categories set out above (designated 1–6 in Section 2). This enables us to observe fluctuations between predominant categories of flags. The results are presented in Figure 2 below.

	Good flags, good suggestions	Good flags, bad suggestions	Plausible flags	Uncertain flags	Bad flags	Bad data
Flags 1-50	34	2	3	2	6	3
Flags 51-100	17	4	3	6	16	4
Flags 101-150	7	2	8	4	25	2
Flags 151-200	9	1	4	9	27	0
Flags 201-250	8	1	2	3	38	0
Flags 251-300	4	2	7	6	31	0
Flags 301-350	5	0	6	4	32	3
Flags 351-400	2	1	3	9	34	1
Flags 401-450	3	0	4	6	36	1
Flags 451-500	2	2	3	9	33	1
All flags	**91 (18.2%)**	**15 (3%)**	**43 (8.6%)**	**58 (11.6%)**	**278 (55.6%)**	**15 (3%)**

Fig. 2. Distribution statistics for the first 500 flags in LD1, contained in the sample report, broken down by every fifty flags. It is important to note that if we wanted our statistics to look impressive, we could stop after the first 50 flags, rather than run our experiment on the first 500. The point, however, is not to produce impressive statistics, but rather to develop the most useful tool to support philological research. Bad flags, as we argue below, are useful for analysis and development.

Based on the statistics of Figure 2, the distribution of all flags in LD1 is visualized below in Figures 3 and 4.

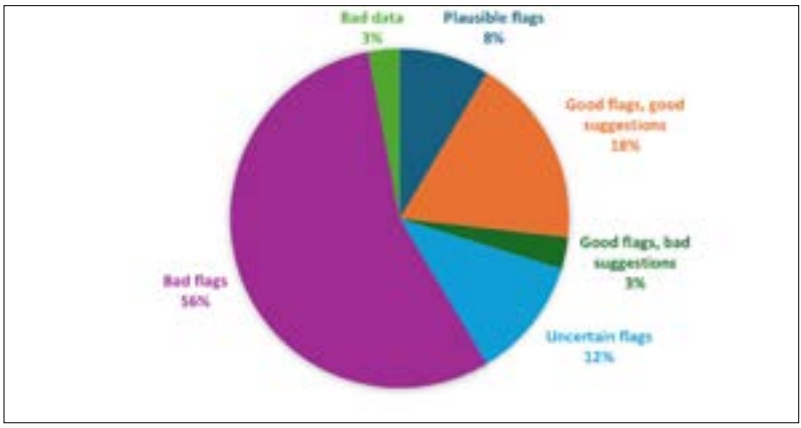

Fig. 3. Distribution statistics for the first 500 flags in LD1, contained in the sample report, by percentage.

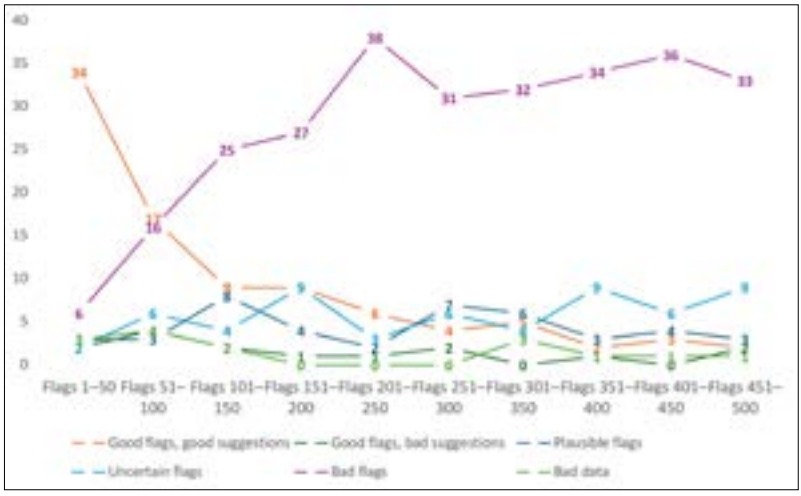

Fig. 4. Distribution statistics for the first 500 flags in LD1, contained in the sample report, broken down by every fifty flags. What deserves attention here is the rather constant number of uncertain flags: these are often philologically significant and reward scholarly attention.

After accounting for all flags, we use the same method for the five subcategories of 'good flags, good suggestions' (designated a–e in Section 2). Figure 5 presents the result broken down into blocs of fifty, while Figures 6 and 7 visualize the distribution of 'good flags, good suggestions'.

	Digitization	Printed edition, typo	Printed edition, MS misreading	Printed edition, editorial	Scribal	Total
Flags 1-50	12	9	10	1	2	**34**
Flags 51-100	2	1	6	1	7	**17**
Flags 101-150	1	0	4	1	1	**7**
Flags 151-200	3	0	2	1	3	**9**
Flags 201-250	1	0	3	1	3	**8**
Flags 251-300	0	0	2	0	2	**4**
Flags 301-350	0	0	2	1	2	**5**
Flags 351-400	0	0	1	0	1	**2**
Flags 401-450	0	0	2	0	1	**3**
Flags 451-500	1	0	0	0	1	**2**
Total	**20 (22%)**	**10 (11%)**	**32 (35.1%)**	**6 (6.6%)**	**23 (25.3%)**	**91**

Fig. 5. Distribution statistics for all 'good flags, good suggestions' in the sample LD1 report, broken down by every fifty flags.

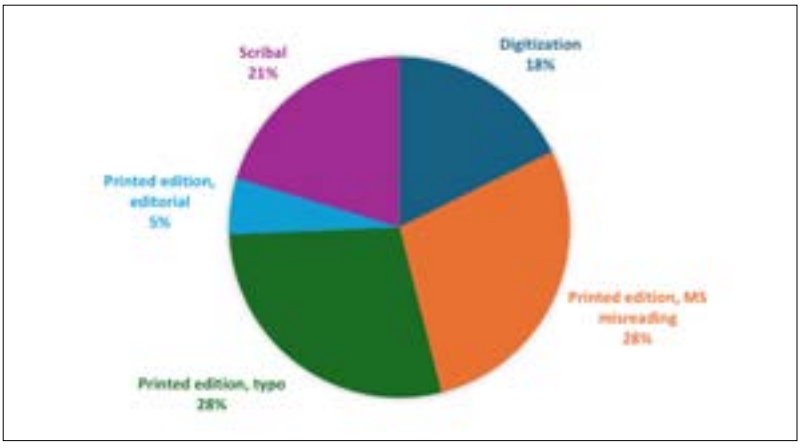

Fig. 6. Distribution statistics for all 'good flags, good suggestions' in the sample LD1 report, by percentage.

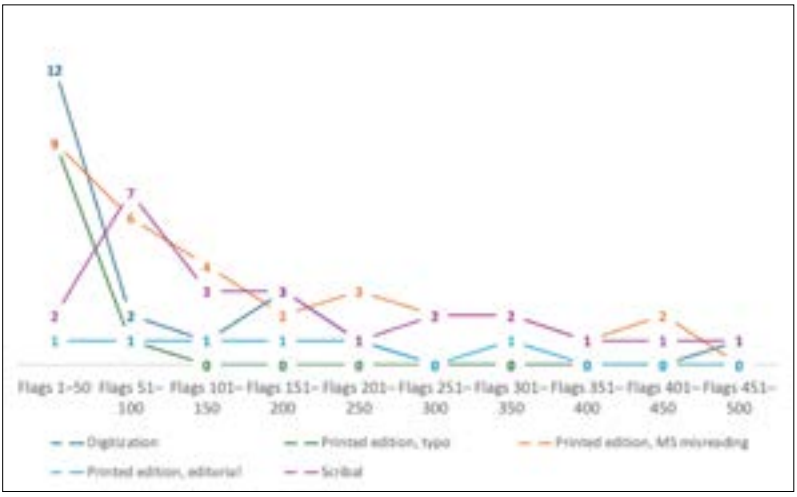

Fig. 7. Distribution statistics for all 'good flags, good suggestions' in the sample LD1 report, broken down by every fifty flags. For philologists interested in identifying scribal errors, rather than simply using Logion to counteract errors introduced in the process of printing or digitizing, it is advisable to read through reports beyond the initial flags.

Figure 2 shows that good flags tend to cluster at the top of the report, especially within the first fifty flags where they are prevalent. As one proceeds down the report, the number of good flags decreases sharply and soon tends toward zero. On the other hand, bad flags are initially scarce but increase significantly until their numbers stabilize in the thirties range. Figure 3 illustrates that, despite minor fluctuations, these two trends (marked by the orange and purple lines) by and large mirror each other.

From these observations, we may conclude, first, that using the chance-confidence ratio (the ρ number) as an ordering principle for flags in a Logion report is sound in principle. Furthermore, it seems justified to set a limit of four to five hundred flags per report, as the verdict of Logion tends to correspond to that of human philologists near the top of the report, while such correspondence becomes increasingly rare as one moves down the report – which indicates that by the standard of human philologists, the likelihood of Logion generating good flags beyond Flag 500 is low. We deem it appropriate, therefore, to use the ρ number as an ordering principle and set the number of flags in a report to no more than five hundred.

In terms of raw statistics, then, Logion reports exhibit an exponential decline from top to bottom. However, the statistical success

observed at the top of a Logion report does not straightforwardly translate into philological value. As Figures 5 and 6 illustrate, 'good flags' in the categories of 'digitization' and 'printed edition, typo' are especially numerous within the first fifty flags, from which peak they quickly decline.[13] To understand this trend, it may be useful to recall that Logion is trained to replace a less likely reading with a more likely one based on the chance-confidence ratio. It therefore stands to reason that many of the top flags in a Logion report concern words that are not actually Greek. Such errors typically emerge in the process of digitization or of preparing printed critical editions. Because they result in words that are not viable Greek, they are most likely to be identified with high confidence by Logion, and Logion's suggestions to substitute non-words with actual Greek words are most likely to be correct.

However, Logion's proficiency in addressing comparatively trivial problems of this kind comes at a philological cost, since the Greek produced by medieval scribes rarely reaches the level of triviality of a mere typo. In other words, the most interesting philological problems are not normally of a kind that can be solved by identifying and correcting instances of impossible Greek. Therefore, although Logion flags near the top of a report are often classified as 'good flags, good suggestions', they hardly ever produce philologically significant results. They are, in a sense, a new and more accurate type of spell check.

By contrast, flags that reward philological attention are distributed more evenly throughout our sample report. Figures 5 and 6 indicate that this is true, to varying degrees, of all three other subcategories of 'good flags, good suggestions', namely 'printed edition, manuscript misreading', 'printed edition, editorial', and 'scribal'. Such cases tend to be of interest to human philologists because they concern substantive issues that have not been resolved by previous editors. Additionally, Figures 2 and 3 show that plausible and uncertain flags, many of which concern problematic passages transmitted by a single manuscript witness, are also more evenly distributed; as are the philologically interesting 'good flags, bad suggestions'.

To sum up, because Logion operates on an algorithm that is drastically different from how human philologists approach textual problems, philologists using Logion reports to emend Psellos' text should bear in mind that high success rates near the top of a report do not necessarily

[13] The only such 'good flag, good suggestion' in the bottom half of the sample LD1 report is Flag 456 (*Theol.* I, 49.35 Gautier): πας → παν, an error of digitization.

translate into high philological interest. Philologically significant flags are rather scattered throughout a report, and it is therefore paramount to devote close attention to each flag. More generally, the significance of individual flags will always to some extent depend on the interests and objectives of the user. While detecting trivial typos may be important in some contexts, such as compiling errata to accompany a print edition or correcting a digital database, especially when it was compiled with the help of OCR, philologists preparing a new edition or wishing to assess the quality of a manuscript will typically need to take a more eclectic approach.[14] In all this, it is useful to bear in mind the difference between how human readers understand Psellos' text and Logion's own *modus operandi*. While the machine identifies a mathematically defined problem and offers a statistical solution, it is ultimately the responsibility of the human user to decide if the problem is indeed a problem; if the solution is indeed a solution; and, lastly, how much weight should be attached to either. To adapt what M. L. West has said about manuscripts, philological problems "must be weighed, not counted".[15] It is with this reminder that we move on to discuss cases where Logion flags as possibly corrupt portions of text that seem to us perfectly fine.

4. *Analyzing 'Bad Flags'*

As things currently stand, 'bad flags' make up over half (55.6%) of all flags generated by a typical Logion report and represent the largest single category – at least when we run the report down to 500. As we explained in Section 2, these flags are labelled 'bad' because we judge the text to make perfect sense. Studying disagreements between humans and machines can be valuable for computer scientists seeking to improve an algorithm, for example, by incorporating additional methods of filtering or refining results. For philologists, studying these flags is beneficial because they reveal patterns in how Logion 'works', thus providing context for the evaluation of individual flags.

Let us first consider possible reasons why humans and machines may disagree. Logion's decision to flag a word as suspicious and suggest an

[14] Further discussion and examples in Haubold's contribution to this volume, chapter 3 , esp. 70-90.

[15] West 1973: 49.

alternative is invariably guided by one principle: the suggested word will always have a higher likelihood of occurring in a given context than the flagged word. In other words, Logion always prefers a mathematically more likely reading over a mathematically less likely one. This is in striking contrast with a well-known principle in human philology, which is that we should prefer the less common, more difficult, reading (*lectio difficilior*) over the easier one (*lectio facilior*). All things being equal, scribes tend to gravitate toward less difficult readings. Often these easier readings are also statistically more likely, but not always. Conversely, as West points out, there is an "important difference between a more *difficult* reading and a more *unlikely* reading".[16] In case of a 'good flag', the mathematically less likely reading happens also to be philologically less likely (or, as is often the case, simply impossible), leading human experts to agree with the machine's assessment. In case of a 'plausible' or 'uncertain flag', the textual problem is often more intricate, and human philologists may find the flagged word possibly but not definitely corrupt. In case of a 'bad flag', however, Logion diverges from the opinion of human scholars: what it deems mathematically less likely proves to be philologically preferable, and what Logion prefers as mathematically more likely is philologically problematic.

The abundance of bad flags in a Logion report underscores the basic truth that mathematical likelihood is not a reliable guide to solving philological problems. Indeed, delving deeper into 'bad flags', we can identify specific areas where Logion's statistically based approach is prone to failure. The rest of this chapter aims to identify such areas of vulnerability and, in so doing, to provide basic guidance for users of Logion in evaluating individual flags. We also think our analysis can lead to some improvements in machine learning, as we explain below.

One common type of bad flag concerns changes from less to more common **case forms**. In practice, Logion tends to change nouns in oblique cases into nominative cases or forms with what seem to be 'nominatival' endings, even when they are not grammatical nominatives. (The latter may be observed, for example, with neuter nouns of the third declension ending in -ος or dative singular nouns of the first declension ending in -η, where the machine ignores *iota* subscript). The dative case, which experienced declining usage in Byzantine Greek, is particularly susceptible to Logion's normalizing efforts, sug-

[16] West 1973: 51.

gesting that statistical biases and the historical development of Greek as a language are sometimes aligned.[17]

Of the twenty-four unsuccessful flags involving case forms in LD1, eight result from Logion changing a dative form into a nominative or nominatival form.

> Example.
> Flag 323 (*Theol.* II, 1.88 Duffy and Westerink): ψαλμοις → ψαλμος.

Logion also tends to change genitives into nominatives or nominatival forms, though this tendency is less pronounced.

> Examples.
> Flag 91 (*Theol.* II, 6.180 Duffy and Westerink): γραφομενου → γραφομενος (true nominative)
> Flag 483 (*Or. fun.* 10.30.24 Polemis): θερους → θερος (nominatival; in practice neuter accusative singular)
> Flag 484 (*Poem.* 68.7 Westerink): σης → ση (nominatival; in practice feminine dative singular)

Rare case forms like the vocative are also vulnerable to misplaced attempts at emendation on the part of Logion.

> Examples.
> Flag 136 (*Poem.* 21.127 Westerink): οφι (vocative) → οφις (true nominative)
> Flag 414 (*Ep.* 210.58 Papaioannou): αριστε (vocative) → αριστα (nominatival; in practice neuter accusative plural)

A related type of bad flag concerns changes in grammatical **gender**. Logion frequently queries feminine forms, which are less common overall, in favor of masculine or homophonous neuter counterparts. Seven flags fall into this category. Four of them involve articles, two pronouns, one a participle, and one a noun.

> Examples.
> Flag 261 (*Or. fun.* 5.3.11 Polemis): τη → τω (article)

[17] On the Byzantine dative see further Böhlig 1958: 116-23.

Flag 491 (*Or. min.* 31.149 Littlewood): αυταις → αυτοις (pronoun)
Flag 196 (*Or. fun.* 1.47.31 Polemis): βουλομενη → βουλομενω (participle)
Flag 224 (*Hist. brev.* 87.18 Aerts): μεριϛ → μεροϛ (noun, neuter in -οϛ)

In Flag 224, the suggested substitution is a neuter noun but the problem aligns with Logion's tendency to prefer the ending -οϛ, typically denoting a masculine nominative singular noun.

After flags affecting grammatical case, the second most prevalent category of bad flags concerns **tense**, with a total of eighteen flags in the sample report. Logion is particularly inclined to suspect the future tense and suggest more common verb tenses, such as present or aorist. Verbs or participles in the future tense are flagged eleven times, and among these, Logion substitutes future with present nine times.

Examples.
Flag 130 (*In Ar. phys.* 303,7 Benakis): εσται → εστι
Flag 201 (*In Ar. phys.* 45,24 Benakis): φησει → φησι
Flag 242 (*Ep.* 61.21 Papaioannou): εξω → εχω
Flag 405 (*Poem.* 53.738 Westerink): δεξεται → δεχεται

Flags 130 and 242 which concern two problematic verbs – ἔχω and εἰμί – will be discussed in greater detail below. Less frequent is the substitution of a future tense with the aorist or a non-verbal form.

Examples.
Flag 335 (*Psych.* 3.13 O'Meara): ερειν → ελειν (aorist infinitive)
Flag 271 (*Or. pan.* 17.212 Dennis): εξω → εγω (pronoun)

Other tense changes also conform to Logion's general preference for more commonly attested forms. In the following two cases, where the flagged word occupies the same metrical position in two very similar verses, Logion simplifies the pluperfect to the perfect tense.

Examples.
Flag 221 (τὴν γὰρ ὑπόκρισιν αὐτοῦ 'ἀλλοίωσιν' εἰρήκει, *Poem.* 54.985 Westerink): ειρηκει → ειρηκε
Flag 404 (τὴν γοῦν ὑπόκρισιν αὐτὴν ἀλλοίωσιν εἰρήκει, *Poem.* 1.106 Westerink): ειρηκει → ειρηκεν

No convincing philological arguments can be offered to overwrite the less common (and thus 'more difficult') pluperfect tense.

To be considered in conjunction with tense changes are flags concerning changes of **mood**. Again, Logion opts for more common forms. Examples are less numerous, with a total of eight flags, but all show Logion's preference for the indicative mood, four substituting the optative mood, three the imperative mood, and one the subjunctive mood.

> Examples.
> Flag 161 (*Ep.* 182.14 Papaioannou): τυγχανοις (optative) → τυγχανεις (indicative)
> Flag 189 (*Theol.* I, 73.69 Gautier): εχοιμεν (optative) → εχομεν (indicative)
> Flag 117 (*Or. for.* 1.1639 Dennis): ορατω (imperative) → ορατε (indicative or imperative)
> Flag 390 (*Theol.* I, 49.11 Gautier): εστω (imperative) → εστι (indicative)
> Flag 398 (*Psych.* 3.13 O'Meara): δεη (subjunctive) → δει (indicative)

Note that Logion struggles with optative forms of ἔχω, as seen in Flag 189 and two other flags. Together with Flag 390 they illustrate Logion's general problem with the very common words ἔχω and εἰμί, on which more below.

Another category of bad flag that we wish to highlight here involves **person** changes in verbs and pronouns. Logion often suspects the second person because it is rarer than the first and third. Out of a total of fourteen bad flags of this type, nine concern the second person. Logion proposes to emend a second person verb or pronoun to one in the first person four times, to an article three times, once to a third-person verb, and once to a particle.

> Examples.
> Flag 220 (*Log.* 6.26 Duffy): σοι → μοι (first-person pronoun)
> Flag 191 (*Ep.* 455.17 Papaioannou): σου → του (article)
> Flag 141 (*Ep.* 241.4 Papaioannou): μενης → μενη (third-person verb form)
> Flag 395 (*Or. pan.* 11.70 Dennis): σε → γε (particle)

As these examples also illustrate, Logion has a more general tenden-

cy to err with common shorter words, such as articles, particles, and pronouns.

Next, we consider two major types of bad flag, beginning with Logion's preference for **articles** with a total of seventeen flags. Particles such as τε and δή, negative particles such as οὐ and μή, as well as relative, indefinite, and possessive pronouns such as οἷς, τι, and σῆς tend to be substituted by the more common article.

> Examples.
> Flag 87 (*Psych*. 62.25 O'Meara): μη (negative particle) → τη
> Flag 156 (*Poem*. 54.243n Westerink): οις (relative pronoun) → τοις
> Flag 83 (*In Ar. phys*. 348,26 Benakis): τι (indefinite pronoun) → το
> Flag 254 (*Ep*. 270.5 Papaioannou): σης (possessive pronoun) → της

Flags 87 and 83 represent common types of substitution, while the last example intersects with Logion's bias against the second person. Because these short words derive much of their meaning from context, it is unsurprising that Logion's treatment of them often seems unsatisfactory to philologists. That said, there are cases where Logion offers very helpful suggestions concerning particles.

Another type of bad flag is associated with two 'articular' forms: **ο** and **η**. Logion tends to substitute isolated *omicrons* and *etas*, most often with a comma, as a way of signaling deletion. (Logion cannot currently delete tokens, only substitute them). This affects *omicron* in six cases and *eta* in seven. *Omicrons* are often deployed by Psellos as the masculine nominative singular article to substantivize participles and participial phrases. Logion tends to let the participles stand on their own and considers the article extraneous in otherwise complete sentences. *Etas* can represent a range of things in a script without diacritics or *iota* subscript, from verb forms to the article or a particle. Logion is not always successful in distinguishing these possibilities and thus tends to err. We provide two examples:

> Flag 249 (*Theol*. II, 34.64 Duffy and Westerink): ο → ,
> Flag 89 (*In Ar. phys*. 399,6 Benakis): η → ,

In Flag 249, the article is used with a participle as a substantive: ὁ πιστεύων. Deleting it, as Logion has suggested, does not significantly

impair the grammar but undermines the overall sense the sentence conveys. In Flag 89, the comparative particle ἤ is expelled by Logion, perhaps because it immediately follows φανείη, thus forming what might seem like a dittography.

Two verbs with which Logion has particular problems – **ἔχω** and **εἰμί** – offer instructive insight into the machine's overall performance. ἔχω is wrongly flagged a total of eight times. Four times a future tense is changed into the present, on two occasions an optative is changed into an indicative, once an imperative is substituted with an indicative present, and once a future becomes the pronoun ἐγώ. Only two flags in LD1 concern εἰμί, but they chime with what we find in the case of ἔχω: a future tense is changed into a present in Flag 130, and an imperative becomes indicative in Flag 390. Flags concerning these verbs suggest that Logion's bias against less common tenses and moods becomes particularly acute with words that are themselves very common.[18]

We have seen several major categories of bad flag where Logion opts for the *lectio facilior*. Other less common but still noticeable patterns of this kind concern crasis, which Logion dislikes because it is rare (e.g., Flag 299 ~ *Or. min.* 37.313 Littlewood: καυτος → αυτος); deictic pronouns ending in *iota* (e.g., Flag 79 ~ *Log.* 28.11 Duffy: τουτι → τουτο); *alpha* privative (e.g., Flag 298 ~ *Or. min.* 31.116 Littlewood: αδιαφορον → διαφορον), and so forth.

We should add that not all bad flags are suitable for typological analysis; and that all tendencies outlined above have exceptions. By way of concluding this section, we offer examples that go against the grain of what we have just set out. We do this to reinforce the central point of this chapter, which is that flags must be assessed individually, and users of Logion need to pay critical attention to every flag, regardless of general trends and tendencies.

First, the following two flags run against the expectation that Logion tends to suspect second-person forms.

> Examples.
> Flag 310 (*Ep.* 193.26 Papaioannou): μοι (first-person pronoun) → σοι
> Flag 384 (*Ep.* 421.2 Papaioannou): ερει (third-person verb) → ερεις

[18] One way of mitigating against this problem may be a procedure known to computer scientists as TF-IDF, see Wu et al. 2008. We are planning to explore this possibility in future iterations of Logion.

Both these flags are considered 'bad', despite appearing to contradict the principle of *lectio facilior*. In the first case, Logion may have been conditioned by the subsequent phrase δώσοντά μοι ... σοι πέμπειν. Similarly, in Flag 384, the second-person σοῦ in ὁπόσα αὐτὸς ἐπὶ τοῦ σοῦ δικαστηρίου συνείρων ἐρεῖ may have prompted Logion to change the third-person verb to the second person. These two examples suggest that Logion's decision-making may be led by information gleaned from a word's immediate context rather than the more general tendencies observed above. Flags such as these, which go against Logion's general tendencies, reward careful examination, even when they are ultimately deemed philologically 'bad'.

Secondly, some bad flags defy Logion's tendency to swap in articles for less common words. In the first example cited below, the machine replaces an article with indefinite τι; in the second, an article is changed into the negative particle οὐ.

> Examples.
> Flag 274 (*Log.* 7.75 Duffy): το → τι
> Flag 439 (*Chron.* 3.23.11 Renauld): ο → ου

Flag 274 seems to defy a common pattern of substitution (cf. Flag 83, τι → το, discussed above). Contrary to this general tendency, Logion may be conditioned here by καὶ τί θαυμαστὸν εἰ ... (*Theol.* II, 3.327 Duffy and Westerink), an expression similar to καὶ τὸ θαυμαστόν, ὅπου ... in our passage. One may venture a similar explanation for Flag 439. In changing the relative clause ὃ τοίνυν ἄλλως μοι εἴρητο into οὐ τοίνυν ἄλλως ..., Logion may be influenced by the expression οὐ + particle + ἄλλως which is commonly found in Psellos. These two flags remind us that Logion, not unlike human philologists, relies on textual parallels for its assessment of specific readings, even if we cannot know for sure, at present, which parallels weigh the most in the results it produces. Indeed, it would appear that Logion also weighs the parallels it identifies, and that, in this case, they are strong enough to overturn the machine's general tendencies towards what is statistically most common overall. Despite promising signs that immediate context matters, Logion's inability to differentiate between patterns that are significant and others that are not often results in a flag being discarded.

With that observation, we return to a point that has formed something of a *Leitmotiv* throughout this chapter, which is that human experts need to evaluate whatever Logion suggests. This is true even when it comes to the most confident machine suggestions – those too

can turn out to be poor, from a human philological perspective. Conversely, though, common patterns of 'bad flags' can occasionally result in convincing machine suggestions for emendation. For example:

Flag 24 (*Laud. in Jo. Crust.* l.268 Gautier): αυλαις → αυλοις.

Logion substitutes a feminine with a masculine form, in a manner that seems consistent with the pattern of 'bad flags' defaulting to masculine forms noted above. However, in this case switching from feminine to masculine is in fact justified. Though similar in form, αὐλή and αὐλός have clearly distinct meanings and the context – ἐρρέτωσαν Αἰσχύλοι καὶ Στησίχοροι **αὐλαῖς** μέν, ὡς λόγος, εἰδότες ἴσως δὲ καταθέλγειν τοὺς πλείονας ('To hell with the Aeschyluses and the Stesichoruses ?from the courts? for all that, as they say, they can charm the masses') – requires αὐλοῖς, the musical instruments, rather than αὐλαῖς, 'courts' ('To hell with the Aeschyluses and the Stesichoruses for all that they can, as they say, charm the masses with their flutes'). Here the scribe simply made an error, as recognized by Antony Robert Littlewood in his edition of Psellos' *Oratoria minora* (Leipzig 1985).[19] Unlike the previous two sets of bad flags, this final good flag reminds us that the mathematically more likely reading is sometimes also philologically preferable.

Conclusion

In this chapter, we have focused on the nature and structure of a Logion report set at LD1 and running to 500 flags, exploring how philologists may best use such a report to assess model performance, as well as improve the text of Psellos along the way. In Section 1, we described how Logion identifies and solves philological problems by assessing the mathematical likelihood of a word occurring in a given context. In Section 2, we outlined a basic typology that can be used for assessing machine results. We emphasized the importance of expert philologists independently evaluating flags, rather than relying on machine-generated statistics. In all cases, philological expertise is required to evaluate whether a potential textual problem identified by Logion is in fact a

[19] *Or. min.* 37.260 Littlewood: ἐρρέτωσαν Αἰσχύλοι καὶ Στησίχοροι **αὐλοῖς** μέν, ὡς λόγος, εἰδότες ἴσως {δὲ} καταθέλγειν τοὺς πλείονας.

problem and, if so, whether Logion's proposed solution actually improves on the text.

In Section 3, we evaluated model performance according to the categories we set out in Section 2. Tables and figures illustrated the algorithm's relatively high level of success in rectifying trivial textual errors early on in a report. Philologically more significant flags, by contrast, were found to be distributed much more evenly throughout the report, calling for careful treatment on a case-by-case basis. Finally, in Section 4, we considered cases in which the model failed to produce convincing results and tried to identify recurrent patterns in machine errors. Logion tends to prioritize statistically more common forms irrespective of context. For example, it is liable to swap out less common case endings for more common ones and replace rare tense forms. Moreover, it shows a marked preference for articles. We also identified related problems such as unjustifiable changes in gender, person, and mood, as well as problems with some very common words such as ἔχω and εἰμί. Some of these problems can be addressed through further training and development. We concluded with some examples that defy typological analysis, emphasizing the need for paying critical attention to each case.

Ultimately, what we have stressed throughout this chapter is the collaborative nature of working with Logion – and the dual purpose of such work. The model can help better understand and edit the text of Psellos. At the same time, by engaging with the model and assessing results, we can provide machine-actionable feedback. What we offered here is an example of how users can profit from a model like Logion and how they can, in turn, give useful information for further development.

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Yuecheng Li and Johannes Haubold

6. The Potential and Limit of Logion Reports*

The rise of artificial intelligence poses a question to philology which is older than Logion, the deep neural network at the heart of this volume: what is the role of automation in this discipline? In this paper, we test the potential and limits of Logion's results by analyzing examples from three different reports which suggest emendations of an increasing degree of complexity. In all cases, Logion's emendations need to be evaluated by a human expert. Based on our examples from the three Logion reports, we argue that Logion is most useful for the human philologist in identifying the minor errors mostly contained in the first report. We also find, however, that some of the uncertain suggestions in the other two reports prove to be the most interesting. Logion's capacity, therefore, is not restricted to its most mechanical results: both Logion's best and most interesting suggestions show the real potential of the collaboration of automation and human philological expertise.

Keywords: Philology; Artificial Intelligence; Reports; Limit; Potential; Ancient Greek; Premodern Greek

Introduction

In a fundamental study of classical philology as a collaborative effort,

* Although the paper was conceived and written collectively by the authors, for the purposes of Italy's *determinazione analitica del contributo individuale*, the sections "The *Distance 1* Report" and "The *Distance 3* Report" should be attributed to Jakob Barnes, while the sections "The *Distance 2* Report" and "Using All Three Reports at the Same time" should be attributed to Maria Giovanna Sandri. We wrote together the introduction and the final paragraph "The Importance of Human Mediation".

Barnes, J., Sandri, M.G. 2025. "The Potential and Limit of Logion Reports" in Battezzato, L., Graziosi, B., and Haubold, J. eds. Artificial Intelligence and Greek Philology: An Experiment, Pisa: 135-161.

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Sebastiano Timpanaro defined "mistaken and reactionary" any hostility to the use of automation.[1] His statement, arguably linked to his commitment to materialist progress, anticipated several developments in contemporary philology, including those outlined in this volume. We are now, for the first time, able to work with artificial intelligence as we edit premodern texts. In this chapter, we give a practical account of what this work involves, focusing on different types of reports generated by Logion, the first deep neural network trained to perform philological tasks. As explained also in other contributions to this volume, Logion assists philologists in detecting and emending errors in ancient and medieval Greek texts. Logion locates potential errors and offers suggestions for emendation, using the vast corpus of pre-modern Greek literature on which it has been trained to identify problematic or unidiomatic usages of grammar and diction and propose corrections. The errors which Logion identifies may be manuscript errors, or else they may derive from errors in the print edition on which the digital text was based or from new errors arising during the process of digitization. Among the suggestions Logion makes for emendation, those that prove useful can be divided into three basic categories.[2] First, Logion identifies an error and offers an emendation with which we, human philologists, agree; second, Logion correctly identifies an error, regardless of whether or not philologists agree with its proposed emendation; third, Logion identifies an error that is itself, in our estimation, wrong, but draws the philologist's attention to a sentence or a nearby word which is deemed to be in need of possible emendation.

In this paper, we consider three different error-detection reports on some of the works written by the Byzantine author Michael Psellos and assess their effectiveness with respect to the three categories of philological assistance just outlined. Each of these reports filters results according to a different Levenshtein distance: 'distance 1', 'distance 2', and 'distance 3'. Roughly speaking, Levenshtein distance corresponds to character distance: simply put, in report 'distance 1', Logion filters out all suggestions except those which emend by one character, 'distance 2' by two characters, and 'distance 3' by three[3]. The different reports may treat the same error, though proposing different emendations based on their respective filters: for example, as discussed

[1] Timpanaro 2005: 89 n. 18. On this quotation see also at the end of our article.

[2] Li and Haubold offer a more fine-grained typology in chapter 5 in this volume.

[3] See further Brooks and Cowen-Breen, chapter 4 in this volume.

below, Logion emends nonsensical αω to ηδη in the 'distance 3' report (a difference of three characters), while the 'distance 1' report emends to correct ανω (a difference of only one character). We are aware, and would like to make our readers equally aware, that we are assessing results at an early stage of development for Logion as a model. We do so now for two reasons: first, to provide feedback that can aid its development, and second, to demonstrate that already at this stage engaging with machine-learning methods leads to significant results from a philological point of view.

At a later stage of development, filters by Levenshtein distance will be integrated into our front-end design in a manner that will allow one to aggregate results, or keep them separate. At this stage, the separate reports enable us to adjudicate between the different kinds of suggestions Logion makes and their respective usefulness, from banal to sophisticated to implausible. This contribution thus focuses on the virtues of each of these reports, considering their value both when used individually and when used in combination. Where Logion appears both wrong and unhelpful, we consider what this tells us about its current limitations, how to maximize the effectiveness of Logion as a tool, and the persistent importance of human mediation and philological expertise. We conclude by emphasizing the role of the human philologist, without whom Logion's suggestions are undecipherable and cannot be adjudicated. We also consider the usefulness of Logion as a tool for identifying errors that have passed unnoticed and for spurring philologists to consider unthought-of suggestions and reconsider previously unamended, but potentially problematic, portions of text.

The 'Distance 1' Report

The 'distance 1' report produces the highest number of good results, since in this report Logion considers possible errors which it would emend by a difference of a single character, and therefore includes many simple errors such as typos. This means that there is a larger number of banal errors and few surprising or unexpected suggestions for emendation. However, at the end of this section we will consider the limitations of considering the 'distance 1' report in such a rigidly quantifiable manner, exploring cases where emendation proposals are helpful but flawed, and so not resolved by a single character change. In those cases the report alerts readers to more interesting textual problems.

Good Flags / Good Suggestions

Some of the errors flagged by Logion turned out to be misreadings present only in the TLG and not in print editions. In these cases, Logion's suggestions matched the text of the relevant print editions. The value of these corrections seems to us twofold: first, they improve the accuracy of the TLG; second, they confirm that Logion is capable of convincing work. We produce some examples below, with the text of the TLG cited first, followed by that of the print edition and Logion's suggestion:

Log. 3.68 Duffy ἄω (TLG) > ἄνω (print edition = Logion's suggestion)
Ep. 165.6 Papaioannou ἄ > ἄν; *Theol.* I, 60.15 Gautier εἰ > εἰς
Or. hag. 3a.657 Fisher οἳ > οἵς
Theol. I, 24tit. Gautier εἰ prior > εἰς
Log. 2.12 Duffy τέχνα > τέχναι
Log. 6.65 Duffy μέ > μέν
Or. for. 1.1632 Dennis τού > τούς
Theol. I, 24.247 Gautier ἀνειρεῖ > ἀναιρεῖ
Or. pan. 13.64 Dennis φιλανθρωπία > φιλανθρωπίας
Or. pan. 2.652 Dennis βασιλίας > βασιλίς
Ep. 67.65 Papaioannou ἔν > ἦν
Hist. Brev. 75.20 Aerts οὐ > σύ
Log. 27.22 Duffy Ἐβγραίοις > Ἑβραίοις
Or. min. 35.38 Littlewood ἐτράφη > ἐστράφη
Or. for. 8.119 Dennis φίλος > φίλοις
Theol. I, 78.6 Gautier πεντακισχιλίου > πεντακισχιλίους
Log. 18.205 Duffy ἔχι > ἔχει
Theol. I, 53.3 Gautier πρό > πρός.[4]

Most of these errors would be easily detectable even without Logion, but Logion makes it possible to find them more quickly and with greater accuracy than human eyes could do. This also demonstrates one of the ways in which Logion may be helpful to modern philology more generally: detecting and weeding out simple but pernicious errors which are first introduced in the process of digitization and then often go unnoticed. Clearly, Logion did better with the list of correc-

[4] This variant was added by the editor: the TLG has πρό, but the print edition actually has πρός.

tions above than the Correction and Verification system (V&C) used by TLG for error detection.[5]

In other cases, errors are equally banal but more deep-rooted. Some of Logion's suggestions turned out to be correct after we double-checked the manuscript(s): in this case, the critical apparatuses of print editions were inaccurate or failed to mention all variant readings in the manuscripts. Most of these errors must have originated as misreadings of the manuscript(s) or simply as typos on the part of the editors. Some examples:[6]

In Ar. Phys. 79,5 Benakis ἀδριαντοποιητική (print edition) > ἀνδριαντοποιητική codd. = Logion's suggestion
In Ar. Phys. 401,1 Benakis εἰ > εἰς codd.
Or. for. 8.103 Dennis ἀγωρισμένα > ἀφωρισμένα cod.
In Ar. Phys. 277,2 Benakis λέει > λέγει codd.
In Ar. Phys. 331,6 Benakis κνήσεως > κινήσεως codd.
Log. 28.3 Duffy μετοπώρᾳ > μετοπώρῳ cod.
In Ar. Phys. 370,7 Benakis τοῦτον > τοῦ τόν codd.
In Ar. Phys. 400,31 Benakis τᾶς > ταῖς codd.
Or. fun. 3.6.41 Polemis δὲ > γε[7] codd.
Or. for. 4.193 Dennis τόν > τό cod.
Or. fun. 1.29.36 Polemis τά > τάς cod.
In Ar. Phys. 371,4 Benakis τόπου > τόπον codd.
Chron. 5.6.12 Renauld τουσοῦτον > τοσοῦτον codd.
Ep. 105.5 Papaioannou σοι > σου (P)[8]
In Ar. Phys. 78,25 Benakis πρόκειται > πρόσκειται codd.

[5] See https://stephanus.tlg.uci.edu/history.php.

[6] The examples are presented in the form X > Y, where X is the (wrong) text in the print edition, while Y is the (correct) text in the manuscripts (and Logion's suggestion). Unless otherwise stated, we refer to the critical editions for manuscript shelfmarks. For the commentary on Aristotle's *Physics*, we could not check MS A (Milano, Biblioteca Ambrosiana, H 44 sup.).

[7] This may be a 'silent' emendation on the part of the editor, but transmitted γε (suggested by Logion) works better (the expression πολλοῦ γε καὶ δεῖ is widely attested, at least since Demosthenes; the TLG counts hundreds of occurrences).

[8] This is not absolutely certain, because we could check only P (Paris, Bibliothèque nationale de France, Grec 1182). We do not have access to U (Città del Vaticano, Biblioteca Apostolica Vaticana, Vaticani Greci 1912) and c2 (Heybeli Ada, Παναγία Καμαριώτισσα 64).

Ep. 138.110 Papaioannou αὐτός > αὐτούς codd.
In Ar. Phys. 399,24 Benakis τούτην > ταύτην codd.
In Ar. Phys. 332,7 Benakis κινοῦνται > κινοῦντα codd.
In Ar. Phys. 257,3 Benakis τά > τάς
In Ar. Phys. 302,23 Benakis εὑρέθη > ἐρρέθη (L)[9]
In Ar. Phys. 46,1 Benakis τοῦτο > τούτου codd.
In Ar. Phys. 163,16 Benakis τῇ > τῷ codd.
Log. 32.48 Duffy ὁ > τό codd.
In Ar. Phys. 400,3 Benakis ἔχει > ἔχειν codd.
In Ar. Phys. 66,15 Benakis ἐπιτακτικοῦ > ἐπιτατικοῦ codd.
Theol. I, 48.86 Gautier ᾧπερ > ὅπερ.[10]

Two examples suffice to show the different kinds of errors of this category that Logion is able to identify. For example, τᾶς (sic) instead of ταῖς at *In Ar. Phys.* 257,3 Benakis is certainly a misprint, and the same is true for κνήσεως instead of κινήσεως at *In Ar. Phys.* 331,6 Benakis, τουσοῦτον instead of τοσοῦτον at *Chron.* 5.6.12 Renauld, τούτην instead of ταύτην at *In Ar. Phys.* 399,24 Benakis, and so on. Such typos, however simple, nonetheless escape editors' notice and produce problematic texts which Logion, lacking the human propensity for mistaking similar characters for one another or passing over a misspelt word, is effective at detecting (which is certainly not to deny Logion's flaws). One reason why it seems important to correct these errors is that misspelled words do not show up in TLG searches: the aim here is not just to make texts readable to humans, in other words, but also to machines.

There are also cases that lead us straight to a better consideration of the manuscripts. For example, at *In Ar. Phys.* 302,23 Benakis, Logion's suggestion is found in one of the manuscripts, but is not printed either in the main text or in the apparatus. The print edition has ἐρέθη (sic). When we double-checked the manuscripts, we discovered that MS Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5 actually has the correct ἐρρέθη, which is also what Logion suggests. Meanwhile, somebody, while transcribing the text on TLG, must have tried to emend the text by writing εὑρέθη in place of the incorrect ἐρέθη of the print edition.

[9] MS Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5. Benakis prints ἐρέθη, following the other manuscripts. On this case see also *infra*.

[10] Although MS Firenze, Biblioteca Medicea Laurenziana, Pluteo 57.40 (L) has the dative, MS Paris, Bibliothèque nationale de France, Grec 1182 (P) has ὅπερ.

Alternatively, this is a case in which the TLG error-correction software produced an error while attempting to correct one. In this case, Logion impelled us to return to the manuscripts in order to discover the correct reading which had been misreported by the main editor of the text, and then, as it seems, wrongly emended in the process of digitization. Logion's successful emendation reveals both how the machine learning tool can circumvent human fallibility and how it requires the traditional tools of the human philologist – i.e., confirming a problematic portion of the text through, first of all, recourse to the manuscripts.[11]

Of course, not all good suggestions in the report find confirmation either in the print edition or in the manuscripts, but some are nonetheless right. A few examples:

Laud. In Jo. Crust. 268 Gautier αὐλαῖς > αὐλοῖς.[12]
Ep. 147.14 Papaioannou λίθινον > λιθίνην.[13]
Or. min. 3.103 Littlewood ἀπολαύσοιτο > ἀπολαύσοιτε.

Clearly, the majority of these emendations consists in minor corrections of orthography and/or concordance. This is due to the fact that, as already mentioned, the suggestions given by the 'distance 1' report are changed by only one character in relation to the flagged text. But the 'distance 1' report may also be useful in suggesting more interesting emendations. For example, let us consider the following passage:

In Ar. Phys. 238,24-239,1 Benakis "Καίτοι", φησίν, "ἀπορήσειέ τις, εἰ τὰ πάθη" καὶ αἱ ἕξεις κινήσεις, "ἡ δὲ λευκότης πάθος", ἄρα καὶ κίνησις. Ἀλλὰ μὴν κινεῖταί τι μέλος εἰς τὴν λευκότητα.

"Yet" - he says "one may then encounter the following difficulty: if affections" and states of mind are movements "and whiteness is an affection", is it therefore not also a movement? And yet, a limb(?) moves into whiteness.

Logion flags τι and suggests το. On closer inspection, the problem lies in the following word, μέλος ('limb', 'part'), which does not make

[11] For further discussion of similar cases see Haubold, chapter 3 in this volume.

[12] The same oration was edited by A.R. Littlewood (*Or. min.* 37.260), who emended αὐλαῖς to αὐλοῖς, i.e. Logion's suggestion.

[13] Elsewhere Psellos seems to treat λίθινος as a three-ending adjective (cf. e.g., *HB* 70.61 Aerts and *Theol.* I, 109.68 Gautier).

sense here. We checked the manuscripts,[14] and they do not read τι μέλος, but actually τι μέλαν, which is certainly right ("what is black moves towards whiteness").

Elsewhere, Logion's suggestion reproduces Psellos' source text:

Log. 55.15-7 Duffy Τὸ γάλα ψυχρὸν ὂν θερμαίνει, ὅτι αἷμά ἐστι λελευκωμένον[15] ὑπ' ἀδένων λευκῶν καὶ ἀναίμων καὶ ἧττον θερμὸν ὂν τοῖς μαστοῖς μεταβαλλόμενον.

The cold milk warms, because it is blood made white by white and bloodless glands, and, being less warm, it is transformed ... (ὂν) the breasts.

Logion flags ὄν and suggests εν instead. Indeed, the source of this passage, Alex. *Probl.* 3.3.6, has ἧττον θερμῶν τῶν ἐν τοῖς μαστοῖς μεταβάλλεται ("...it is transformed by (glands that are) less warm than the ones in the breasts"), which confirms that ἐν is needed before τοῖς μαστοῖς. One could emend the passage on the basis of Alexander (reading θερμὸν ὄν as θερμῶν τῶν ἐν): as Johannes Haubold pointed out to us in a personal communication, assimilation to preceding ψυχρὸν ὄν provides a plausible *Fehlergenese* which accounts for both θερμόν and ὄν. In the manuscript these two phrases occur in successive lines, diagonally below each other, so the error might have been caused by a slip of the eye. Furthermore, MS Oxford, Bodleian Library, Barocci 131 (O) is a notoriously corrupt manuscript, and confusion of ον and ων is not at all uncommon even in more reliable witnesses.[16]

Consider also the following, more uncertain, passage:

Log. 3.106 Duffy (= Chaer. fr. 2 van der Horst) οὗτοι γὰρ πρῶτοι τὴν ψυχὴν ἀπαθανατίσαντες ἕλξεσι καὶ πλάναις ἀμυθήτοις ἠνάγκασαν καὶ μέχρι πόας καὶ λίθου καταβιβάσαντες αὖθις εἰς τὴν οἰκείαν ζώνην ἀποκατέστησαν.

For they [*sc.* the Egyptians] were the first people to represent the soul as immortal and they compelled it with unspeakable attractions and wanderings

[14] B (Paris, Bibliothèque nationale de France, Grec 1920), C (Paris, Bibliothèque nationale de France, Grec 1947) and L (Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5). We could not check MS A (Milano, Biblioteca Ambrosiana, H 44 sup.).

[15] Although this word was not flagged by Logion, the TLG wrongly reads λελυκωμένον.

[16] Cf. Reinsch 2014: XXXVI-XXXVII.

and, having forced it to come down even into grass and stone, they restored it again to its own zone [transl. P. W. van der Horst].

This is a very obscure passage, as already noted by P. W. van der Horst.[17] The exact meaning of ζώνην ('belt', 'zone'?) is not clear. Logion suggests ζωήν instead of ζώνην. On the one hand, a return movement 'to one's own spot' (ζώνη in the sense of 'zone' instead of 'belt' is attested at least since the second century BCE: see e.g., Posidonius in *Str.* 2.2.2) is well suited to words such as ἕλξις and πλάνη, and ζώνη is attested elsehwere in discussions of Chaldaean teachings (*Psych.* 147.5 *et passim* O'Meara; *Psych* 150.10 O'Meara). On the other, the expression ἀποκαθίστημι + εἰς ζωήν ("to return to life") finds a parallel in Psellos in *Theol.* I, 17.58-9 Gautier εἰς τὴν αἰωνίαν ἀποκαταστᾶσι ζωήν ("restored to eternal life"),[18] the expression οἰκεῖα ζωή was used frequently by Psellos,[19] and from a palaeographic point of view the *Fehlergenese* is easily explainable by the simple addition of a ν (also, the corruption of ζωήν into ζώνην may have been facilitated by the preceding words of motion). However, Logion's suggestion, meaning that "they [*sc.* the Egyptians] return the soul to its own life", does not make more sense than the transmitted text. All this considered, even though Logion's suggestion may be incorrect, it is worth noting that it provides a novel conjecture to a problematic passage. One may object that Logion's suggestion trivializes the text, and it can hardly be considered a certain emendation, but it is worthy of consideration and perhaps would be worth mentioning in the apparatus of the print edition.

Logion may also be useful in cases where the editor is uncertain whether to emend or not, although the fact that a variant reading is suggested by Logion does not establish that it is right "per se". For

[17] Van der Horst 1984: 52: "Here wisdom appears to be identical with magic. The details are not clear; ἕλξις, πλάνη, ζώνη seem to be magical technical terms. At the background is perhaps the Egyptian concept of the *ba* as a bird with human head descending to the grave after wandering away from it".

[18] In general, this was a common expression in Byzantine sacred texts (cf. e.g., Ps.-Macar. *Serm.* 10.4.4.1 ἀποκαταστήσει εἰς ζωὴν αἰώνιον). On ἀποκαθίστημι + εἰς + acc. in antiquity, see e.g., Aristot. *Magn. Mor.* 2.7.10 ἀποκαθισταμένοις εἰς φύσιν, and *Met.*1074a3 εἰς τὸ αὐτὸ ἀποκαθιστάσας.

[19] See e.g., *Chron.* 6.27.19 Renauld τὸ βραχύτατον μέρος τῆς οἰκείας ζωῆς; *Or. for.* 4.201 Dennis οἰκείαν αἱρεῖσθαι ζωήν; *Psych.* 38.28 O'Meara τὴν οἰκείαν ἀνελίττει ζωήν; *Theol.* I, 88.51 Gautier τὴν οἰκείαν ζῶντες ζωήν.

example, with reference to *Log.* 6.68-9 Duffy ὁ δ' ἄλλος οὐ πάντως πάντων αὐτῷ τούτῳ συγκεκοινώνηκεν ("but the other has not fully shared all with this one"), the editor notes *an* τούτων *scribendum*? ("or should τούτων be written?") in the critical apparatus. Indeed, Logion suggests τούτων in place of τούτῳ, which is certainly preferable ("but the other has not fully shared with him all these"). The same is true of *Log.* 49.69 Duffy τὸ δὲ 'σύντομος' πρόκειται ("the word 'σύντομος' is set before"), on which the editor noted "immo πρόσκειται" ("the word 'σύντομος' is added") in the apparatus. Πρόσκειται is also what Logion suggests. In these cases, the machine neither offers a novel emendation nor confirms as certain an existing emendation. Rather, operating on very different principles from those of a human philologist – establishing mere probability of a given reading on the basis of the corpus of Greek literature on which it has been trained, and of the Psellian corpus on which it has been finetuned – Logion may prompt us to reconsider existing human emendations, on the basis that we now have one more 'opinion', or rather machine learning method, supporting the same conclusion.

Good Flags, Bad Suggestions

Not all good flags (i.e., correctly identified errors) in the 'distance 1' report are accompanied by good suggestions. In some cases, this seems to be because Logion is unable to suggest lacunae or deletions, something that we hope more developed versions of the model will be able to do. Nevertheless, for some of these flags it is possible to supply an emendation that begins from Logion's suggestion, even if its emendation is not correct "per se".

For example, in the following passage, Logion, constrained by the requirement to make an emendation of a difference of one character, flags ου and suggests ο instead:

Psych. 7.15-8 O'Meara οὐ γὰρ ἰσημερινὸς πρὸς ὀρθὰς τέμνει τὸν ζῳδιακόν.

For the equator does not cut the ecliptic at right angles.

Οὐ was conjectured by Linder, *cl.* Procl. in *Tim.* 238.1-10 οὐδὲ γὰρ ὁ ἰσημερινὸς πρὸς ὀρθὰς τέμνει τὸν ζῳδιακόν. The manuscripts actually read ὁ, just as Logion suggests: ὁ ἰσημερινὸς πρὸς ὀρθὰς τέμνει τὸν

ζῳδιακόν.[20] However, the negation cannot be simply replaced by the article, because Psellos certainly knew that the equator was inclined with respect to the ecliptic, and this awareness is needed to make his argument work here.[21] Still, Logion rightly points to the fact that the article is needed here. Thus, one may want to write, similarly to Proclus, ο<ὐ> γὰρ <ὁ> ἰσημερινός, or ὁ γὰρ ἰσημερινὸς <οὐ>, as Luigi Battezzato suggested to us in a personal communication (in this case, οὐ might have been deleted due to haplography in light of the preceding ending -ος). These emendations would retain what is correct and valuable in Logion's suggestion, while preserving a greater concern for the sense of the passage as well as due skepticism towards an over-reliance on Logion.

Another example:

In Ar. Phys. 279,21-3 Benakis Καὶ εἰ μέν εἰσι τὰ ὑποτεθέντα ἀδιαίρετα τῆς κινήσεως, τὰ Δ Ε Ζ, κινήσεις, κινήσεως παρούσης ἐνδέχοιτο ἂν μὴ κινεῖσθαι [...], εἰ δὲ οὐ κινήσεις, ἀλλ' ἀδιαίρετα ᾗ πᾶσα κίνησις οὐκ ἐκ κινήσεων ἔσται ἀλλ' ἐξ ἀδιαιρέτων κινημάτων.

And if the supposed indivisible elements of the motion, δ, ε, and ζ, are motions (themselves), we should have to say that a thing, while in motion, might not be moving [...] but if they are not motions, but (still) indivisible, then every motion won't be made up of motions, but of indivisible movements.

Logion flags ᾗ, suggesting a comma instead. This led us to review the manuscripts; it turned out that MS L (Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5) actually reads "ἀλλ' ἀδιαίρετα, ἡ πᾶσα κίνησις", with comma after ἀδιαίρετα and reading η as a feminine article, which is certainly right.

These are satisfactory solutions to problems highlighted by Logion but then not solved adequately by machine-learning methods. As may be expected, there are also cases in which we, as human philologists, could not arrive at a convincing emendation for a passage flagged by Logion as problematic. Here is an example:

[20] Venezia, Biblioteca Nazionale Marciana, Greci Z 524 (M) and Firenze, Biblioteca Medicea Laurenziana, Pluteo 58.29 (f^1).

[21] See previously (ll. 13-5) γίνονται δὴ δύο κύκλοι, καὶ τούτων γεγονέτωσαν ὁ μὲν ἐντός, ὁ δὲ ἐκτός, λοξοὶ πρὸς ἀλλήλους ("two circles result, and of these one shall be internal, the other external, being oblique to each other").

Or. fun. 10.14 Polemis Ὡς δὲ διήμαρτε τῆς ἐφέσεως ἀπεῖναι τοῦτον μαθών, εὐθὺς ἢ λόγος πέμπει τοὺς ἄξοντας, ἐν οἷς Ἀλέξιος ἦν.

When he failed to achieve what he desired having learned that he had left, ... (ἢ) immediately sent people to fetch (him), among whom there was Alexios.

Logion flags ἤ and suggests ο, instead. There is certainly something wrong with this passage: the function of ἤ is not clear, and λόγος ('discourse') cannot be the subject of πέμπει ('sent'). Logion's suggestion does not solve the problem. What we would rather expect here is something like εὐθὺς ὁ Βασίλειος πέμπει τοὺς ἄξοντας <αὐτόν> ("Basileios immediately sends some people to bring (him) the monk"), which would however deviate considerably from the transmitted text. Johannes Haubold suggested to us to indicate a lacuna (after λόγος?), while Luigi Battezzato proposed to emend εὐθύς into εὐθύ<τερο>ς ("quicker than a word he sends"); all these options look possible. Speculation aside, we can conclude with a degree of certainty that in this case Logion drew our attention to a passage that is very likely corrupt but had not been previously identified as such.

In one passage, to which we have returned several times, we consider it possible, though not certain, that the transmitted text is in fact sound:

Or. hag. 6.65-9 Fisher εἰ δὲ πρὸς ἀναλογίαν ἐθέλοις τῆς ἔξωθεν εὐπρεπείας τὸ ἐνδότερον κάλλος ὁρᾶν, ταινίαι ἅμα μὲν αὐτῇ ἡ ἀκριβὴς περὶ τὸ θεῖον ὑπόληψις, τὸ λογικὸν τῆς ψυχῆς περισφίγγουσα καὶ τὴν πλάνην ἀφαιροῦσα τῆς ἐπὶ θάτερα μέρη κινήσεώς τε καὶ μετανεύσεως.

But if you want to see the internal beauty by way of analogy with the external appearance, then altogether her (Mary's) bands represent her exact grasp of the divine, tightly binding the logical part of the soul all round and removing any deviation of movement and inclination in either direction.

The 'distance 1' report suggests μα instead of ἅμα, while the 'distance 2' report suggests α.[22] It seems clear that Logion's intention (to speak in terms of human motivation, as one finds it difficult to avoid doing when working with the machine) is to remove ἅμα altogether. According to the critical apparatus, ταινίαι ἅμα μὲν αὐτῇ is the text

[22] Report 3 does not consider this passage.

transmitted by MS Αθήνα, Εθνική Βιβλιοθήκη της Ελλάδος (EBE), 282 (a), while MS Αθήνα, Εθνική Βιβλιοθήκη της Ελλάδος (EBE), 327 (h) has ταινία μὲν αὐτῇ.[23] We suggest retaining plural ταινίαι as the *lectio difficilior*, supported by a reference to plural ταινίαι λαμπραί just before (*Or. hag.* 6.47 Fisher). Nor is there a problem with the lack of verb: one can simply supply εἰσί(ν). The difficulty is with ἅμα, hence its removal in one manuscript as well as Logion's attempt to remove it. Psellos typically uses ἅμα unambiguously, either as a preposition with dative or else as an adverb with a τε ... καί or καί ... καί construction. In order to understand the present passage, ἅμα must be taken very loosely with the several sentences which follow, as Psellos proceeds to offer analogies for the jewelry worn by Mary in an image he is describing. Johannes Haubold suggests to us that ἅμα may be used to link the present analogy to those which follow and is balanced by ὁμοῦ later on in the text (*Or. hag.* 6.78 Fisher). As far as we can see, Psellos does use ἅμα loosely at times, but it is difficult to parallel the manner in which this encompasses several sentences here (we would expect something much simpler, like πρῶτον). Still, it is hard to account for the corruption, since the sense of the passage does not demand a different word, and if we simply remove ἅμα, as MS Αθήνα, Εθνική Βιβλιοθήκη της Ελλάδος (EBE), 327 does and Logion attempts to do, we fail to explain how it ended up in our text.

All these examples reveal both the opportunities and some of the limitations of working with Logion. A 'distance 1' report can, strictly speaking, only suggest emendations of one character, resulting in many successful but ultimately banal suggestions. Good emendations, as determined by the human philologist, are not necessarily limited to one character, but here we have seen that these too may be inspired by a 'distance 1' report. In some cases, Logion's suggestion of a single character change prompted us to explore other options, including what would count for Logion as a change of several characters or even a lacuna, which Logion cannot suggest at all. Such are the limitations of Logion that we certainly cannot assume its suggestions to be *prima facie* correct. However, by taking Logion as a prompt to revisit troublesome passages, and by using its suggestions as a springboard for our own attempted emendations, Logion proves to be useful to the human philologist without at any point being capable of replacing human philological expertise.

[23] These manuscripts were not accessible to us.

The 'Distance 2' Report

In our discussion of a sample 'distance 1' report, we offered several instances of Logion's suggestions being substantiated by a reassessment of the manuscripts or of the print edition. 'Distance 2' reports generate similar cases. For instance, at *Chron.* 4.7.8-9 Renauld the TLG text has κερίττων, while the print edition has the correct κρείττων, which is what Logion suggests; at *Ep.* 126.1 Papaioannou, Logion suggests οὐδέν for the TLG's [Οὐ] δέν, which is indeed confirmed by the print edition; and at *Log.* 51.697 Duffy the TLG lacks a high dot after εἰσι, which Logion recommends, and which is also found in the print edition. Elsewhere, the manuscripts substantiate Logion's suggestions. For example, at *In Ar. Phys.* 230,15 Benakis, Logion suggests a full stop instead of δή. We checked the manuscripts and discovered that Laur. Plut. 87.5 (L) has a high dot right before πῶς, which is certainly needed here. These cases, from the flags that we have analyzed, tend to be relatively simple, though the last example shows that they are not restricted to the correction of mere typos.

A 'distance 2' report may also supplement and improve upon a flag correctly identified in a report set to Levenshtein 'distance 1', but not there brought to a satisfactory conclusion. For example:

Chron. 6.85.10-2 Renauld ὡς δ' οὐκ ἦν ἀποδείκνυσθαι τὰ λεγόμενα, ἀγνώστους τινὰς ἱππέας ἐπ' ἄντην ὡρμηκότας ἐλογοποίουν ἐκκεφαλίσαι.

But since it was not possible to prove these words, they made up a story that some unknown knights beheaded him after rushing against (him).

In this case, the 'distance 1' report flags ἄντην and suggests αυτην instead, which cannot be right. The word ἄντην appears to be flagged correctly, however, since the expression ἐπ' ἄντην is not otherwise attested, nor does it seem likely that ἐπ' is to be attached to ὡρμηκότας as a case of tmesis (ἐφορμάω, 'to rush upon'). Logion may provide the correct emendation in the 'distance 2' report, where it suggests αυτον (l. αὐτόν) rather than αυτην ("after rushing against him"); one may compare a few lines above (ll. 5-6): ὁρμήσαντες ἐπὶ τὸν νεκρόν ("rushing against the corpse"). Indeed, if we look at the more recent edition of Psellos' *Chronographia* by D. R. Reinsch, we learn from the apparatus that ἐπ' αὐτόν is what we read in Constantine Sathas' and Salvatore Impellizzeri's editions, while MS P (Paris, Bibliothèque nationale de France, Grec 1712) has ἐπ' ἀν τὴν. Another possible emen-

dation for ἐπ᾽ ἀν τὴν, suggested to us by Luigi Battezzato, is ἐναντίον *vel* ἐναντίως.

Further cases may be adduced where the 'distance 2' report we considered for this chapter offered the same flag as the 'distance 1' report but improved upon its suggestion. In the following example, the suggestion in the 'distance 2' report also finds confirmation in the manuscripts:

In Ar. Phys. 19.21-2 Benakis ὥστε εἶναί τι αὐτῇ ἑκάτερον, τὸ ὑποκείμενον καὶ ὃ συμβέβηκεν.

So that each is to her both the subject and the attribute.

The 'distance 1' report suggests αυτο instead of transmitted αὐτῇ. The correct solution is provided by the 'distance 2' report: αὐτῶν ("so that each of the things is both the subject and the attribute"). Indeed, αὐτῶν is what manuscript Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5 (L) reads, as is shown in the critical apparatus of the print edition. In this case, Logion's suggestion in the 'distance 2' report clearly surpasses that of report 'distance 1,' and prompted us to revisit both the print edition and the manuscripts. The correct reading, though known to the print edition's editor, was unduly neglected.[24] In terms of developing Logion, one possibility here might be to use 'distance 1' to identify possible textual corruptions but then broaden to 'distance 2' or '3' in order to look for possible solutions that are not as constrained.

Consider yet another example:

In Ar. Phys. 8.24,10 Benakis μὴ κινείσθω δὲ παρ᾽ ἄλλου, τὸ δὲ Β κινείσθω ὑπὸ τὰ Α.

Let it not be moved by another, but let *B* be moved by *A*.

The 'distance 1' report suggests το instead of τά, but the problem is not singular vs. plural. Rather, we need a genitive of agent where both the TLG text and Benakis' print edition have the accusative τά. In the 'distance 2' report Logion does indeed suggest this emendation. When

[24] For discussion and further examples of this phenomenon, specifically in relation to MS L of the Aristotle commentary, see Haubold's discussion in chapter 3 in this volume.

we checked the manuscripts,[25] we discovered that they do in fact read τοῦ; τά must be a misprint.

Like the 'distance 1' report discussed earlier in this chapter, our sample 'distance 2' report sometimes combines good flags with suggestions that point in the right direction while not being fully satisfactory in themselves. Sometimes, the reason is again that Logion is currently unable to indicate lacunae. Consider the following passage:

In Ar. Phys. 359,24-360,1 Benakis "Καὶ χωρὶς δὲ τοῦ ὁρισμοῦ τῆς κινήσεως" καὶ ἄλλος "πᾶς τις ὁμολογήσειεν", ὡς "τὸ δυνατὸν κινεῖσθαι" "ἀναγκαῖόν" ἐστι καί ποτε "κινεῖσθαι".

"And quite apart from the definition of movement", "everyone else(?) would admit" that "anything that is capable of moving" "of necessity does move" at some point.

The 'distance 2' report suggests αν instead of πᾶς. The passage that is being discussed by the commentator, Arist. *Phys.* 251a12, has πᾶς ἂν ὁμολογήσειεν. Logion made us check the manuscripts: while B (Paris, Bibliothèque nationale de France, Grec 1920) and C (Paris, Bibliothèque nationale de France, Grec 1947) have ἄλλος, which is reproduced in the print edition, Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5 (L) actually has ἄλλως, which is certainly right. While Logion is technically wrong to suggest removing πᾶς for ἄν, it in fact identifies the problem correctly and can, with some caution, be used to good advantage.

The effectiveness of the 'distance 1' report in producing many good but banal corrections is not paralleled in report 'distance 2.' Yet, while the 'distance 2' report does not contain as high a number of correct flags and correct suggestions as report 'distance 1,' the preceding examples show that it does contain many of the same kinds of flags and can be used broadly the same ways as report 'distance 1.' To conclude our discussion of report 'distance 2,' we consider one of the more interesting suggestions we encountered:

Log. 16.277 Duffy αὐτίκα ἡ οὐρὰ τοῦ κυνὸς τῷ νωταίῳ μέρει συνῆπται τοῦ σώματος, ὃ καθάπερ ἐκ πηγῆς τοῦ ἐγκεφάλου τοῖς σπονδύλοις

[25] B (Paris, Bibliothèque nationale de France, Grec 1920), C (Paris, Bibliothèque nationale de France, Grec 1947) and L (Firenze, Biblioteca Medicea Laurenziana, Pluteo 87.5). We could not check MS Milano, Biblioteca Ambrosiana, H 44 sup.

συγκαθηλούμενον ἄχρι τοῦ τελευταίου μέρους τοῦ †κοϊκοῦ† διατέταται σώματος· αἰσθητικώτατον δὲ τὸ μέρος καὶ ποταμὸς ἀληθῶς τῆς τοῦ ἐγκεφάλου πηγῆς.

The dog's tail is attached directly to the back part of the body, which being firmly attached to the vertebrae, extends as if from a spring from the brain up to the last part of the (?) body. That part is most perceptive and truly a river issuing from the spring of the brain.

†κοϊκοῦ† is a known crux in this passage. In his print edition, Duffy chooses not to emend, but prints *leg. ζωϊκοῦ vel κυνικοῦ*?, which seems less than satisfactory. Logion suggests λοιποῦ "rest of", which though we were dissatisfied with Duffy's suggestions in the apparatus criticus, we were initially inclined to reject. We first considered two possibilities of our own: πρώτου and κοίλου. Κοίλου would make it easy to explain the textual corruption from a palaeographical point of view. Furthermore, in several places Psellos refers to parts of the body as κοῖλος: in one of his poems, the artery is κοῖλον τι σῶμα "a hollow body" (*Poem.* 9.294 Westerink); elsewhere he refers to "the hollows of the joints" τὰ κοῖλα τῶν ἄρθρων (*Chron.* 6.127.8 Renauld) and hollow veins τῆς κοίλης φλεβός (*Log.* 16.121 and 123 Duffy), and even of the hollow of a head διὰ τοῦ κοίλου τῆς κεφαλῆς (*Log.* 18.249 Duffy), though of the heads of cuttle-fish and octopuses rather than human beings. Nevertheless, it is difficult to make a case for the appellation of the body itself as "hollow", or else the vertebrae or the dog's head. As for the other possibility, τὸ πρῶτον σῶμα would mean "the main body" in the sense of "the main (part of the) body", i.e., the bust; for this meaning see later on in the passage: ᾧ δὴ καὶ ἡ οὐρὰ συγκειμένη μεταλαμβάνει τῆς αἰσθητικῆς δυνάμεως καὶ τῷ πρώτῳ συγκινεῖται σώματι ("(the back,) with which the attached tail also shares the perceptive power and moves along with the primary body"). The main disadvantage of this emendation is that it is difficult to explain paleographically. We then returned to Logion's suggestion, and we discovered that λοιπὸν σῶμα is a common collocation in Psellos' work, e.g., "the helmet protects the head, and the armour holds the rest of the body" καὶ τῇ μὲν κεφαλῇ κράνος ἀρκεῖ, τὸ δὲ λοιπὸν σῶμα ὁ θῶραξ ἀμπέχει (*Chron.* 6.133.7-8 Renauld); "as men grow old and grow weak, their nails and hair grows, but the rest of the body fades" Τοῖς ἀσθενοῦσι καὶ γέρουσιν ὄνυχες καὶ τρίχες αὔξουσι, τὸ δὲ λοιπὸν σῶμα φθίνει (*Log.* 55.295-6 Duffy); "his head and the rest of his body are rather small" τῷ δὲ καὶ ἡ κεφαλὴ καὶ τὸ λοιπὸν σῶμα βραχύτερον (*Encomium in matrem* 335 Criscuolo);

etc. Psellos tends to use τὸ λοιπὸν σῶμα in *contrast* with the head, so the expression would fit well here. All things considered, it seems to us that Logion's suggested emendation of λοιποῦ is plausible, and could at least be included among the other suggestions in the apparatus criticus.

Regardless of whether or not λοιποῦ should be adopted, we concluded that Logion provided a novel suggestion to a known crux which, upon careful examination, was shown to be well-founded on Psellos' idiom.

The 'Distance 3' Report

In report 'distance 3,' where Logion is capable of suggesting changes to 3 characters, the accuracy of the suggestions diminishes overall. There are many reasons for this, and it is ultimately unsurprising that Logion should be less effective where it is most able to invent and deviate far from the transmitted text, but one consideration that should be kept in mind yet again is Logion's inability to suggest lacunae. Emendations that require a change of at least 3 characters often point to larger problems, such as a word (or more) dropping out, a need to recognize in one nonsensical word two correct but separate words, etc. Logion is largely incapable of these emendations.[26] Logion in the 'distance 3' report has a tendency to flag the same passages as reports 'distance 1' and 'distance 2', but with much weaker suggestions: e.g., for transmitted αω (*Log.* 3.68 Duffy), Logion had rightly suggested ἄνω in the 'distance 1' report (see above), which makes good sense and remains close to the transmitted text. In report 'distance 3', however, Logion suggests ηδη for αω, which is far less likely as a corruption and hardly necessary in terms of sense. Likewise, in report 'distance 1', Logion wrongly flags ποτέον in *Or. hag.* 1,b.270-1 Fisher βρωτέον τε καὶ ποτέον αὐτοῖς "it is necessary for them to eat and drink", suggesting δοτεον instead. Clearly, Logion is wrong to attempt to replace the perfectly suited ποτέον with δοτεον, but Logion's error may be at least understood on the basis that 1) it is the only occurrence of ποτέον in Psellos' works, thus indicating one of the limitations of Logion's purely statistical approach; 2) it is a paleographically plausible corruption,

[26] Though for Logion's prowess in working across word boundaries see Haubold, chapter 3 in this volume.

and at least not absurd on that count. In report 'distance 3,' however, Logion wastes the philologist's time by suggesting the implausible and nonsensical ποτα.

We should emphasize here that before our assessment of 'distance 3' we had no empirical data to establish the usefulness of such a report. So, although from a philological point of view, the results are disappointing, from the point of view of learning how to use and develop machine-learning methods, this part of our contribution is, we believe, of value. Put simply, Logion's limitations must be properly understood before one can evaluate its suggestions. Here is an example:

In Ar. Phys. 251,18-19 Benakis Καὶ δῆλον ἐκ τῆς λευκάνσεως καὶ οὗ ἔθηκε παραδείγματος.

That is also clear from whitening and from the paradigm he established.

Logion suggests replacing ἔθηκε with εκ. Such an emendation does not make any sense, until one realizes that Logion does not distinguish between homonyms with different diacritics and accents. Therefore, we would argue that Logion makes this suggestion on the basis of reading the negation οὐ rather than proleptic relative οὗ, in which case, with Logion's emendation, the text would read: "that is also clear from whitening and not from the paradigm", which, though it does not produce good sense in context, is at least a viable sentence (even though we would expect οὐκ before a vowel, this may not be a strong enough factor to affect Logion's reading). Although the idea of scrutinizing Logion's bad suggestions will not appeal to the philologist, for our present purposes it seems important to point out the various sources from which Logion's errors derive. We singled out an interesting case; other sources of error will be less surprising: misunderstanding of Psellos' use of several layers of discourse; very rare names and words, numbers and onomatopoeia, all make an appearance in the 'distance 3' report as well. It is important that the philologist be mindful of how Logion's limitations affect its results so that one handles them appropriately. Even more importantly, a philological scrutiny of results might, we hope, lead to improvements of Logion's design.

Useful suggestions can be found in report 'distance 3,' but they are unquestionably fewer and further between and, where they are found, cannot be adopted *tout court* (at least in our findings) but may perhaps contribute to the human philologist's formulation of a suitable emendation. For example, a doubtful case may be the following:

Log. 48.44-5 Duffy ὅτι μὲν οὖν σοφὸς ὁ ποιητὴς οὐ τὰ ἀνθρώπινα μόνον, ἀλλὰ καὶ τὰ θεῖα καὶ τὰ δαιμόνια, οὐκ ἄν τις ἀντερεῖ τινι, ὅσον μηδὲ κἀμοί·

Indeed that the poet is wise not only in human affairs, but also in divine and spiritual matters, no one would deny to anyone, to such an extent he would not even deny it to me.

Logion here suggests emending μηδέ to γε. The last clause is awkward, the point of the self-reference is not clear, nor the point of ὅσον (nor is it illuminated by the larger context of the passage), but it may not be clear that it needs to be emended. However, Duffy interestingly records as a ms. variant δέ for μηδέ (*ad loc.*), which also attempts to remove the negation. Γε is indeed superior to δέ, as producing a more fluid sentence ("even as much as he should deny it to me"), though it deviates from any transmitted text. Logion's suggestion, by removing the negation, produces less awkward Greek, but it must be said that the sense remains somewhat obscure. If the text is left as it stands in the print edition, Psellos poses as someone whom one might often refute (for reasons that are unclear) but would not in this case; if Logion's emendation is adopted, Psellos still poses as someone whom one might refute (but for somewhat clearer, rhetorical reasons), but the emendation introduces the awkwardness that Psellos excludes himself from the "anyone" referred to by τινι. One last solution should be considered, which is to adopt Logion's emendation but read κάμοι (3rd person singular optative of κάμνω) for κἀμοί: "however much he should toil [at trying to deny it]". Some parallels suggest this may not be impossible: e.g., *Poem*. 67.246 Westerink μὴ τοίνυν κάμνῃς, ἄνθρωπε, τοῦτο κἀκεῖνο λέγων "do not toil, man, at saying this or that thing"; *Ep.* 378.92.20-21 Papaioannou οὐδ' εἰ πολλὰ κάμοις ἐπιχειρῶν τεχνικώτατα "not even if you toil at attempting many skillful things". This is quite speculative, and we need to do more work to reach a satisfactory conclusion, but Logion invites us here to reconsider whether or not we should be satisfied with the text of the printed edition. This case is particularly difficult, since we have two manuscripts reporting discrepant readings, with Logion suggesting a third. None of the readings is obviously sound. We offer here a range of possible solutions, none of which is certain. All we can say is that Logion, combined with human intelligence, contributed to their formulation.

Using All Three Reports at the Same Time

We examined the initial fifty flags of each report. These are our results:

- the 'distance 1' report: 30 good flags / good suggestions, 3 good flags / bad suggestions, 9 bad flags, 4 uncertain flags, 4 N/A.
- the 'distance 2' report: 5 good flags / good suggestions, 11 good flags / bad suggestions, 31 bad flags, 3 uncertain flags.
- the 'distance 3' report: 5 good flags / bad suggestions, 45 bad flags.

Quantifying Logion's success rate is not easy.[27] Many flags and suggestions raise intricate problems, and it is not always possible to establish conclusively whether they are correct or not.[28] In fact, there are many suggestions which are possible in theory, but not certain, and which can therefore not be accepted as "correct" by the editor. Consequently, there are various degrees of "bad" and "good" flags and/or suggestions, in the sense that some are good to a higher degree than others, while others are bad to a higher degree than others.[29] The problem here is that computer models need to train on machine-actionable data, while the humanistic pursuit of making sense of texts is multifaceted and subjective, compelling philologists to simplify results in order to yield such data.[30] That said, providing feedback of the kind we have outlined above can help improve the performance of models like Logion.

Evaluating flags will always be subjective, in that an editor may be more or less conservative, more or less inclined to emend the transmitted text. That said, our view is that the 'distance 1' report, giving the highest number of good results, is clearly the most cost-effective. Nevertheless, the other two reports are not useless, since they also flag corrupted passages that are not flagged by the 'distance 1' report. As shown above, the 'distance 2' report and 'distance 3' also provide good

[27] For a systematic attempt, see Li and Haubold, chapter 5 in this volume.

[28] See above, for example, the case of *Log.* 3.106 Duffy, examined under "the *distance 1* report".

[29] On the subjectivity of philological work, see also Battezzato, chapter 2 in this volume.

[30] See further Graziosi, chapter 1 in this volume.

suggestions for passages that were already flagged by the 'distance 1' report, but with a bad suggestion (see above, under the 'distance 2' report).

All this considered, it is clear that the use of these reports on the part of editors depends on what they aim to gain from Logion. Editors who want to get the most out of Logion and are able to spend a bit more time in going through all three reports (thus being willing to put up with some nonsense, especially in the 'distance 3' report) might want to look at all reports. Editors who, on the other hand, do not have much time to spend on Logion and want to run a quick check might be better served by focusing only on the 'distance 1' report (and perhaps the 'distance 2' report).

There is a further caveat to this conclusion, which we need to highlight here: what we discovered to be the case for Psellos may be different in the editing of other authors. So, again, the only way to make progress is through painstaking assessment of results.

Meanwhile, we think there are some ways in which one can save time when using all three reports. First of all, one may want to avoid considering all the flags of the 'distance 2' report and '3' for which the 'distance 1' report already gave a good suggestion: this diminishes the number of useless flags in those reports. For example, at *In Ar. Phys.* 370,6-8 Benakis Ἔστι δὲ οὗτος ὅμοιος ὁ λόγος ὁ περὶ τοῦ πάντα κινεῖσθαι τῷ περὶ τοῦτον ἕνα ἕκαστον σταλαγμὸν κατατρίβειν, the 'distance 1' report suggests του τον instead of τοῦτον. Logion's suggestion is right and is confirmed not only by the manuscripts (see above) but also by Arist. *Phys.* 253b.14-15 ἔστι δ' ὅμοιος ὁ λόγος τῷ περὶ τοῦ τὸν σταλαγμὸν κατατρίβειν ("the discourse is like that concerning the wearing out of a stone by drops of water"). As a consequence, του suggested in the 'distance 3' report can automatically be discarded.[31] Again, at *Or. for.* 8.103 Dennis the 'distance 1' report flags the *vox nihili* ἀγωρισμένα and suggests αφωρισμενα, which is certainly correct (we checked MS Firenze, Biblioteca Medicea Laurenziana, Pluteo 57.40, which actually reads ἀφωρισμένα: ἀγω- is a misprint, then): ωρισμενα suggested by the 'distance 2' report can thus be ruled out.[32]

Similarly, some flags in the 'distance 2' and 'distance 3' reports can be discarded when it has already emerged from the 'distance 1' report that they are bad. For example, at *Or. hag.* 8.456-7 Fisher the 'distance 1' re-

[31] Report 2 does not comment on this passage.

[32] Report 3 does not consider this passage.

port suggests αφη in place of ἔφη, but the text is correct as it stands (Τὰ μὲν οὖν τῆς εὐλαβείας πῶς ἂν ἐφάψοιτο χόρτος ἔφη πυρός; "words of piety asked how fodder would ever touch fire"); as a consequence, the same flags in the 'distance 2' report, suggesting η, and in the 'distance 3' report, suggesting και, can also be ruled out.

Furthermore, one may want to start from the 'distance 1' report, and then look at the other two reports only when the 'distance 1' report does not provide good suggestions, in order to see whether one can find interesting emendations there (see, for example, the aforementioned cases of *Chron.* 6.85.11 Renauld and *In Ar. Phys.* 19,21 Benakis, under the 'distance 2' report).

When using all three reports, one should keep in mind that all three reports may flag a text with good reason but give an incorrect suggestion; for example, at *Or. for.* 7.109 Dennis τὴν ἐν νόμῳ τούτην διοίκησιν, all three reports correctly flag τούτην; the 'distance 1' report suggests τουτων, 'distance 2' suggests τουτω, 'distance 3' suggests αυτων: yet, the correct reading here is certainly ταύτην (τούτην is a misprint: we also checked the manuscripts,[33] which correctly read ταύτην).

The Importance of Human Mediation

Throughout this chapter, we have considered several instances where Logion correctly identifies errors but where its suggestions need to be modified, or perhaps adopted with a great amount of residual uncertainty. In many of these cases, Logion nonetheless produces a result that is ultimately positive, highlighting previously unnoticed errors; indicating wherein exactly lies a textual corruption; and aiding the search for possible emendations. However, Logion's ability to 'compound' errors must also be considered, and this leads us to stress the importance of human philological assessment when working with Logion. Logion sometimes makes the same mistakes that Byzantine scribes made a millennium ago; in particular, Logion tends to trivialize and standardize the text, thus creating banalizations and repetitions. As a consequence, careful human mediation is essential in evaluating

[33] P (Paris, Bibliothèque nationale de France, Grec 1182) and V (Città del Vaticano, Biblioteca Apostolica Vaticana, Vaticani Greci 672).

the flags and suggestions given by Logion, lest we exacerbate the very problems we mean to solve. Let us consider a few examples.

As for banalizations, at *Ep.* 1.27 Papaioannou, the 'distance 1' report suggests the indicative ἔχει instead of the optative ἔχοι; but the optative is perfectly fine here (see the preceding ναί). Here there are promises of further development, via use of Term Frequency – Inverse Document Frequency (tf-idf).[34] What we want to emphasize here, though, is that such development is a response to philological feedback of the kind offered here. At *Or. min.* 11.27-8 Littlewood ἱδρῶσι, φημί, βίᾳ τοῦ μετώπου καὶ τῆς κεφαλῆς καταρρέουσιν ("they sweat, I mean, they necessarily flow down the front and the head"), Logion suggests δια instead of βίᾳ, but the text works fine as it is: βίᾳ recalls "ἐκ φύσεως" ("naturally") a few words above; the preposition διά is not needed, since καταρρέω + simple gen. means "to flow down sth".[35] At *Ep.* 123.8 Papaioannou ἀνέθηκε τὸ κάτοπτρον τῇ θεῷ ("she raised the mirror to the goddess"), Logion suggests τω instead of τῇ, because in Psellos θεός is normally male; but here θεός refers to Aphrodite: this privileging of male subjects is a common problem in machine-generated texts more generally,[36] so again it may be possible to implement correctives in the course of further development. At *Psych.* 42.1 O'Meara Εἶτα δὴ τὰ τῶν θυομένων περιειργάζοντο πτώματα, εἰ ἐπὶ δεξιὰ πίπτοιεν ἢ ἐπὶ τὰ λαιά "then, they scrutinized the falls of the sacrificial animals, whether they fell to the right or to the left", Logion suggests σωματα for πτώματα in the 'distance 2' report. πτώματα, with the literal meaning of "falls" here, is not the most common Greek usage, but is clearly very appropriate in context. At *Psych.* 13.3-4 O'Meara Πλούταρχος τὴν δόξαν τὸ ἄτιμον μέρος τῆς λογικῆς ψυχῆς ... λέγει "Plutarch says that belief is the dishonourable part of the rational soul", Logion attempts to emend the text in the 'distance 3' report, suggesting τριτον for ἄτιμον. Logion appears to respond to the preceding and following references to the "five powers of the rational soul", and so expects a number rather than an abstract adjective with μέρος. Psellos' text is sound, however, and

[34] See Graziosi, chapter 1 in this volume, together with Li and Haubold, chapter 5 in this volume, who discuss Logion's difficulties coping with optative forms, especially in very common verbs.

[35] Cf. *Or. Min.* 37.274-5 Littlewood καὶ δεινὰ τῶν ὀφθαλμῶν καταρρέειν τὰ δάκρυα ("and terrible tears flowed down the eyes").

[36] See Li and Haubold, chapter 5 in this volume.

corroborated by Philoponus' commentary on Aristotle, citing Plutarch (XV. P.425b12.46ff. Hayduck).

With regard to repetitions, at *Ep.* 201.7-8 Papaioannou Logion suggests ηρκεσε instead of ἤρεσε; ἤρκεσε is a synonym of ἤρεσε, and Logion is trying to repeat ἤρκεσε, already used by Psellos two words earlier (τοῖς δ' ἐς τἆλλα σοφίας ἤρκεσέ τε καὶ ἤρεσε). At *Or. pan.* 2.649 Dennis κακοῦ κακὸν ἀλλαξάμενος ("exchanging a bad thing for a bad thing"), the 'distance 1' report suggests κακον instead of κακοῦ, thus trying once again to standardize the text. At *Log.* 19.60-1 Duffy πάχνη γὰρ ἐπωνόμασται οἷον πεπηγμένη ἄχνη ("πάχνη 'rime' takes its name from πεπηγμένη ἄχνη 'frozen foam'"), the 'distance 1' report suggests παχνη instead of ἄχνη, thus creating another repetition. ἄχνη is certainly right, given that Psellos here suggests an etymology of πάχνη, as coming from πε<u>π</u>ηγμένη <u>ἄχ</u>νη. At *In Ar. Phys.* 275,18 Benakis, εἰ γένοιτο στιγμὴ στιγμῆς συνεχής ("whether a point becomes contiguous to a point"), report 1 suggests στιγμη in place of στιγμῆς, thus trying to make the variant uniform with the preceding word. At *Ep.* 306.3-4 Papaioannou ὀφειλέτης εἰμὶ τοῖς χωρίταις ἀρχαίας ὑποδοχῆς καὶ ἀποδοχῆς ("I am indebted to the locals for their longstanding hospitality and reception"), the 'distance 1' report suggests υποδοχης instead of ἀποδοχῆς, creating yet another repetition.

If Logion flags a reading that is a modern conjecture and suggests instead a reading that is in fact transmitted in a manuscript, the suggestion is not automatically correct. An example of this is *Psych.* 7.15-8 O'Meara, already examined above (see 'the *distance 1* report'). Another case is found at *Psych.* 15.17-8 O'Meara Δημοκρίτου δὲ τοσοῦτον ἀποδέχεται τὴν δόξαν ὅτι ἐξ ὕδατος τὴν ὄψιν γεννᾷ ("(Aristotle) accepts Democritus' opinion to the extent that he generates sight from water"): Δημοκρίτου was conjectured by Hansen, while the only codex transmitting this text, MS Oxford, Bodleian Library, Barocci 131, has the nominative Δημόκριτος. Logion suggests Δημόκριτος (probably because the subject is implied here), but the genitive is certainly needed.

Logion's best and worst flags have something in common, which is that they both require the least amount of human interpretation for their implementation or rejection. Most of the flags we have considered in this paper are of another kind, forcing us to reconsider our transmitted text and the emendations we would supply for it, often without ever reaching a final conclusion, though assisting in adding to the number of suggestions available and at times clarifying the issues at hand. Another way of saying this is that Logion is both at its best and at its worst when its suggestions are most well-suited to a computer: sim-

ple detection of typos, or banalizing errors resulting from insufficiently contextualized statistical calculations. Logion is at its most interesting, however, when its suggestions resemble those of the human philologist: narrowing in on questions which lack a simple solution but lead us to reconsider questions of idiom and meaning.

As mentioned at the beginning of our article, in his 1963 book *The Genesis of Lachmann's Method*, the Italian philologist Sebastiano Timpanaro shows that the method which became standard for collating and evaluating the manuscripts of ancient texts, called "Lachmann's Method", was neither invented nor perfected by Karl Lachmann, who gave it its name. Timpanaro displays in this book a distrust toward the kind of history of ideas which glorifies individual "geniuses" at the expense of the cumulative work of scholars who make invaluable contributions, however neglected their works and forgotten their names may later become. It is in this spirit that Timpanaro, in a footnote, *sotto voce*, appears to prophesy future developments in philology. Timpanaro writes: "More than ever I find mistaken and reactionary any hostility against the methods of automation which is based on rhetorical claims for the uniqueness of the *human spirit*".[37] Timpanaro did not have any such concrete example of an "artificial philologist" before him as the one we have tested and examined in this paper. Nonetheless, his vision of philology would have probably permitted the use of the "artificial philologist" because it was just such work – anonymous, laborious, thankless – that, though overlooked, played a key role in the preservation of ancient texts. In the present paper, our aim has been to show how the human philologist may engage, critically and not naively, with automated philology, making use of it when it is useful, and discarding it when it is not.

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[37] Timpanaro 2005: 89 n. 18. Timpanaro refers to Henri Quentin's revival of Lachmann's method earlier in the 20th century and its more recent uptake by theorists of the automation of philology.

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Jakob Barnes and Maria Giovanna Sandri

7. Machines, Scribes, and Scholars: Comparing Human and Artificial Emendation*

This chapter compares human and artificial emendations to reflect on the role machine learning may play in the future of philology. Focusing on the oeuvre of the Byzantine polymath Michael Psellos, we consider eight machine-generated emendations against decisions and emendations made by past editors and scribes. Our aim is threefold. First, we join other contributions in this volume in showing the kinds of philological problems with which Logion can assist. Second, we reflect on the scribal and editorial history of the texts with which Logion is working. Finally, we hope to offer some examples of how to work through problems with Logion and thus show how machine learning can participate in the philological process as a new source of textual possibilities to be evaluated by philologists as they work to produce the best possible editions of premodern texts.

Keywords: Artificial Emendation; Editorial History; Machine Learning; Philology; Michael Psellos; Ancient Greek; Premodern Greek

Introduction: Humans against Machines – or Better, Humans and Machines

Pitting machines against humans is a popular pastime: audiences saw Garry Kasparov face off against Deep Blue in 1997, Ken Jennings against Watson in 2011, Lee Se-dol against AlphaGo in 2016, and ChatGPT

* Although this contribution was conceived and written collectively by the authors, for the purposes of Italy's *determinazione analitica del contributo individuale*, the "Introduction", "Part 1", and "Part 3" should be attributed to Olivia May, while "Part 2", "Part 4", and the "Conclusion" should be attributed to Leyla Ozbek.

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against any number of journalists and writers in 2022. The intention of this chapter then – to compare human and artificial emendations of Psellos – might seem inherently combative. But as other contributions in this volume emphasize, Logion is no philologist: it offers suggestions for emendation, sometimes good ones, but requires a philologist to evaluate these suggestions on grammatical, stylistic, and paleographical grounds. In fact, machine learning and philology proper draw from different toolboxes. Human philologists study manuscripts to compile a list of variants, from which they will choose the most plausible to reproduce in a critical edition. Logion, on the other hand, has access to a single edition of Greek text and no apparatus criticus; its suggestions derive instead from computed probabilities. That they can reach the same conclusion at all is perhaps more surprising than we tend to acknowledge, and it may be useful to consider some instances in which traditional philology and machine learning overlap in unusual ways.

To that end, this chapter considers eight Logion flags against various forms of human intelligence: emendations made by editors, emendations (or errors) made by scribes, and of course our own evaluations in the process of working with Logion. Our purpose here is threefold. First, we join other contributors in this volume in showing the kinds of philological problems Logion can help identify and elucidate. Second, we hope to reflect, however obliquely, on the scribal and editorial history of these texts. Critical editions are a palimpsest of centuries of philological work, and in working with Logion, we find ourselves encountering these human voices, past and present, in unexpected ways. Finally, we hope to model the process of working through philological problems with Logion, to show how machine-aided philology might work in the future. Philology, after all, has always been a collaborative (if sometimes competitive) effort, continually passing down or striking out editorial decisions of the past in new critical editions. Used properly, machine learning does not undermine this process, but rather participates in it, as a new source of textual possibilities to be evaluated by philologists in their efforts to produce the best possible edition.

1. *Detecting Editorial Error*

Our first three examples deal with cases in which Logion accurately detects editorial error and, by encouraging us to return to the manuscripts, helps us improve the text. At *Or. fun.* 10.20.11-15, Polemis prints the following:

Δεῖ μέντοι γε τὸν ἄριστα τοὺς ἄλλους οἰκονομήσοντα ἑαυτὸν πρῶτον οὕτως οἰκονομεῖν καὶ τὸν τῆς ὑποταγῆς νόμους ἑτέροις νομοθετήσοντα αὐτὸν πρῶτον ὑπὸ τοιούτῳ νομοθέτῃ τετάχθαι καλῶς καὶ παρ' ἐκείνου μαθεῖν τοὺς θεσμοὺς τῆς ὑπακοῆς. **Οἷς** ὁ μέγας οὗτος ἐγεγόνει καὶ μέντοι γε πολλοῖς ἑτέροις καταλέλοιπε ζῆλον τῆς πνευματικῆς ταύτης ἀρχῆς, εἰ καὶ πάντες ἐπίσης τοῦ χαρακτῆρος ἀποτυγχάνουσι, περὶ οὗ δηλώσειν ὁ λόγος βούλεται.

Certainly, it is necessary that the man who will manage others best first manages himself in the same way, and that the man who will lay down the laws of obedience for others has first been ruled well by such a lawgiver and learned from him the laws of obedience. **By these** [?] this great man [Nicolas, founder of the Monastery of the Beautiful Spring at Olympos] lived, and indeed to many others he has left a zeal for this spiritual rule, even though everyone equally falls short of his character, which I now wish to illustrate in my speech.

There is a problem with the phrase starting with οἷς, which has been handled in different ways. Gautier punctuates οἷς ὁ μέγας οὗτος ἐγεγόνει as part of the previous sentence, taking οἷς as a relative dative referring to τοὺς θεσμούς, but the precise meaning here remains unclear. Polemis conjectures <ἮΩν> εἷς in the apparatus criticus, changing the idea to, "This great man was one of these [i.e. men who have learned the laws of obedience]". This reading makes more sense but requires us to assume that the scribe made two mistakes in one brief passage, dropping ὧν and substituting omicron for epsilon. Here Logion came in with the suggestion οἷος, which was immediately attractive for retaining the sense of Polemis' emendation, but with fewer transformations. And in fact, when we checked a digitization of Città del Vaticano, Biblioteca Apostolica Vaticana, Vaticani greci 672, the only extant manuscript, we found that it too points towards reading οἷος (f. 92v):

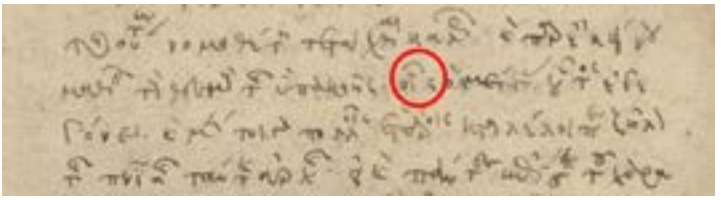

Fig. 1. Città del Vaticano, Biblioteca Apostolica Vaticana, Vaticani greci 672, f. 92v. Reproduction courtesy of the Biblioteca Apostolica Vaticana.

A definitive assessment is difficult without inspecting the physical manuscript (which we were unable to do), but the spacing of letters

and placement of the circumflex suggest that a second omicron may have been written in the Vorlage of Vaticano greco 672 and perhaps was once present also in Vaticano greco 672 itself. Here, then, we can see Logion as an unexpected paleographical aid, assisting us not by engaging with the manuscript directly, but by encouraging us to look more carefully at it.

A similar case in which Logion restores a manuscript reading arises at *Chron.* 6.58.9. The passage is famous: in it, the council of Constantine IX Monomachos reacts to the treaty of φιλία drawn up between Constantine, his wife Zoe Porphyrogenita, and his mistress Maria Skleraina, which allowed Skleraina to move into the palace apartments and granted her the titles of δεσπότις and βασιλίς. Recent editors print the following text:[1]

ἡ δὲ σύγκλητος, ἐπὶ τῷ καινῷ εἰσήεσαν γράμματι, ἐρυθριῶντες μὲν· καὶ τὰ πολλὰ ὑποτονθορύζοντες· ἐπαινοῦντες δὲ ὅμως τὴν συγγραφὴν ὡς ἐξ οὐρανίων καταχθεῖσαν **δέλτον·**

The council entered for the new treaty, blushing and muttering many things under their breath; nonetheless, they praised the treaty like a tablet brought down from the heavens.

The sole manuscript, Paris, Bibliothèque nationale de France, Grec 1712, reads δέλτων; Reinsch and Renauld instead follow an emendation that Konstantinos Sathas printed *tacite* in his 1874 *editio princeps*, δέλτον. Logion, however, proposes a return to δέλτων, and closer investigation of grammatical patterns in Psellos suggests that this, the original manuscript reading, is correct. The text should be translated as, "[They] praised the treaty as though it had been brought down from the heavenly tablets". Psellos tends to use οὐράνιος as an adjective, and where it is a substantive, he includes the article; moreover, we find no parallel instances where the substantive οὐράνιος is used to refer to heaven. On the other hand, "heavenly tablets", "holy tablets", "tablets above" or "from above", and "tablets of God" appear often in Psellos, almost always in the plural.[2] There is therefore no need to correct δέλτων, and the emendation δέλτον in fact deviates from the norm of

[1] Punctation is Reinsch's.

[2] αἱ δέλτοι οὐράνιοι (*Theol.* II 3.88), αἱ δέλτοι ἱεραί (*Theol.* I 57.60, *Ep.* 173.53), αἱ ἄνω δέλτοι (*Ep.* 205.14, *Or. hag.* 5.202), αἱ ἄνωθεν δέλτοι (*Or. fun.* 1.55.40), αἱ Διὸς

Psellos' corpus. Interestingly, then, this is a case where Logion prompts a more conservative editorial decision, despite having no knowledge of the manuscript.

The erroneous modern emendation may derive from a mistaken idea of the phrase's source and referent. Sathas' emendation seems to presuppose an understanding of δέλτος as akin to the first tablet(s) of the Ten Commandments brought down to Moses on Mt. Sinai (Exod. 31:18); that is, he imagines Psellos' treaty enacting a 'physical' movement from heaven to earth. But if we read instead "[they] praised the treaty as though it had been brought down from the heavenly tablets", this understanding becomes less plausible. Rather, Psellos gestures to tablets *in* heaven, and the movement from heaven to earth suggested by καταχθεῖσαν is a transfer of authority and knowledge, rather than the descent of a physical object. Such tablets appear elsewhere in Psellos,[3] and they have a classical lineage.[4] Fragments of Aeschylus and Euripides are the earliest to speak of a Διὸς δέλτος that records human error (Aesch. fr. 281a.21 R; Eur. fr. 506.2 Kn.); Lucian later adopts the image ironically when he calls the accuser of a Greek tutor a "witness from the tablets of Zeus" (ἐκ τῶν Διὸς δέλτων ὁ μάρτυς, *Merc. Cond.* 12). This phrase was eventually cited in several Byzantine proverb collections as descriptive of someone "clear and trustworthy" (ἤγουν ἀναμφίβολος καὶ πιστός, Arsenius, *Apophthegmata* 11.9a von Leutsch; Macarius Chrysocephalus, *Paroemiae* 3.68 von Leutsch). Psellos' use of ἐξ οὐρανίων δέλτων at *Chron.* 6.58.9 (and elsewhere in the corpus) seems to draw from this tradition. Here, then, we may have an instance of human bias intervening in the philological process: the more immediately recognizable image of Moses' tablets has replaced a transmitted reading that aligns more closely with Psellos' style. Logion's computa-

δέλτοι (*Or. pan.* 1.34, *Or. for.* 3.81, *Ep.* 111.56, *Or. min.* 14.92). We observe a single exception in the *Poemata* (21.58-9).

[3] See again footnote 2. Note too the near identical language adopted by Psellos' contemporary Theophylactos in *Ep.* 38, where he describes judges smugly assessing their decrees as though "drawn down from the tablets of Zeus" (εἶδον ὁμοίως καὶ δικαστὰς τὰς οἰκείας ψήφους, κἂν μὴ πάνυ τοι πρὸς τοὺς νόμους ἀποξεσθεῖεν, **ὡς ἐκ Διὸς γοῦν δέλτων ἀνεσπασμένας** ἀσπαστῶς περιέποντας καὶ τοῖς δεδογμένοις ἐγκαρτεροῦντας ἐνστατικώτερον, 38.4-7 Gautier).

[4] As Papaioannou 2019 also traces at *Ep.* 111.56. Critical editions frequently note the precedent of Lucian at instances of αἱ δέλτοι οὐράνιοι *vel sim.*

tions sidestep this problem to present an alternative which has manuscript authority as well as grammatical and semantic viability.

A final example of Logion's utility in detecting editorial error can be seen at *Theol.* I 103.106, where Gautier prints the phrase: αἳ **μὴ** ὑετοῖς καταβρέχονται μήτε χαλάζαις κατακροτοῦνται ("[the mountain ridges] which are not drenched by rain showers nor sound loudly with hail"). Logion proposes μήτε instead of μὴ, and this, we believe, is very nearly correct. Elsewhere Psellos uses the pairing μήτε ... μήτε, rather than the pairing μὴ ... μήτε. Since ὑετοῖς is aspirated, Logion's proposed μήτε should actually read μήθ', which *is* attested in MS L (Firenze, Biblioteca Medicea Laurenziana, Pluteo 57.40). Gautier prints instead the reading of MS P, perhaps because of presumptions about manuscript quality. MS P, the important Paris, Bibliothèque nationale de France, Grec 1182 dated to the late 12th century CE, was long considered the older and superior manuscript, until MS L was redated from the 15th century to the late 11th or early 12th century in the 2010s.[5] Westerink, who curated Gautier's 1989 edition of the *Theologica*, makes explicit his preference for MS P:[6]

has varias recensiones non temere commiscendas esse visum est, sed codicem **P**, nisi ubi vitio manifesto affectus est, praeferendum, ceterorum lectiones, etiamsi forte praestare videntur, in apparatum relegandas.

It seemed to me that these variant recensions should not be mixed at will, but that codex P, except when affected by an obvious error, should be preferred, and the readings of the others, even if they happen to seem superior, should be relegated to the apparatus.

The recent redating of MS L has created a particular need to offset previous editorial bias toward MS P across editions. Logion's lack of engagement with both earlier scholarship and the manuscript tradition can here, paradoxically, be an asset in helping us detect and amend

[5] Bianconi 2010 dates L to the late 11th century, without excluding the possibility of a date in the early 12th century: 96; Papaioannou 2019 opts for the latter: LVIII. On the dating of P, see Papaioannou 2019: LXXVII-LXXVIII.

[6] Gautier 1989: XVI. Cf. Papaioannou's more recent evaluation of L with respect to the *Epistulae*: "**L** shows a clear distance from **P**, with which it shares a large number of texts, and in comparison to which it offers usually (but neither consistently nor often clearly) superior readings" (2019: LXVII).

instances where bias in favor of or against particular manuscripts may have led us astray. Knowledge of manuscript history, age, and quality, of course, remains critical for the philologist; this should always shape our assessment of Logion's suggestions. But by prompting the reevaluation of variants where it is needed, Logion can help as we seek to restore better readings.[7]

2. *Echoing Earlier Conjectures*

While Logion sometimes offers solutions that human editors have not considered, we also see its recommendations echo conjectures that have already been made. For example, at *Theol.* II 3.444, the sole surviving manuscript, Paris, Bibliothèque nationale de France, Grec 1182, reads:

ἄκουσον Ἡσαΐου τοῦ μεγαλοφωνοτάτου τῶν προφητῶν **σοφῶς** τοῦτο κηρύττοντος· 'πνεῦμα κυρίου ἐπ' ἐμέ, οὗ ἕνεκεν ἔχρισέ με·'

Hear Isaiah, the loudest of the prophets, wisely proclaim the following [Is. 61:1]: "The Spirit of the Lord is upon me, on account of which He anointed me."

Logion flags σοφῶς and proposes the emendation σαφῶς. The proposal is attractive from a paleographical perspective as well as a contextual one. In fact, Logion's suggestion has already been advanced by Westerink and Duffy in the apparatus criticus of their edition. While the manuscript clearly has σοφῶς, the slip would be easy for a scribe to make and difficult for others to detect and emend, given the grammatical viability of both readings. The broader context of the passage, too, makes σαφῶς particularly appealing. *Theol.* II 3 is an imperial letter to a sultan following his staging of a religious debate between the Byzantine ambassador and Seljuk sages.[8] Psellos praises the sultan for his tolerance of Christianity and declares his intention to improve the sultan's understanding of the Incarnation and Trinity through the testimony of Old Testament prophets and Greek oracles. For Psellos, then, prophetic clarity is a pedagogical necessity here. His emphasis on clarity emerges

[7] See also the essay by Haubold, chapter 3 in this volume.

[8] See Gautier 1977 on the historical context of such embassies and a conjecture as to the sultan's identity.

not only in the repeated use of σαφής to describe the prophets, cited by Westerink and Duffy, but also in related vocabulary of brightness, purity, and display.[9] In particular, Psellos distinguishes between theological λόγος accessible to purified souls only, "hidden and forbidden... to the many" (ὁ μὲν κεκρυμμένος καὶ ἀπόρρητος ὡς εἰπεῖν τοῖς πολλοῖς), and the λόγος he presents to the sultan, accessible to all through scripture and prophesy (ὁ δὲ προβεβλημένος καὶ τοῖς πᾶσι τηλεφανὴς ὡς ἐρεῖν, *Theol.* II 3.185-87). Psellos' citation of Isaiah 61 here provides a straightforward argument for the Holy Spirit's existence prior to the Incarnation, and it is telling that he offers none of the exegesis provided for other passages. From an interpretive standpoint, σαφῶς chimes with the text's broader emphasis on clarity and Isaiah's particular lucidity regarding the Trinity. While it is difficult to prove that σοφῶς is wrong, σαφῶς, suggested by Westerink and Duffy, as well as by Logion, has a good chance of representing what Psellos originally wrote. In cases like this, of course, it is frustrating not to know why Logion suspects σοφῶς: here the 'black box' aspect of large language models becomes a true limitation, particularly because the model may be basing its recommendations on different evidence from ours.

Logion again replicates a scholarly correction at *Ep.* 201.75-76, where Papaioannou prints:

αὖθις δέ μοι λογισμὸς ἐπάνεισιν ἕτερος, **μή πω** οὐ θεῖον τὸ ὅρμημα, καὶ πράξαντι ἀκολουθήσῃ μετάνοια.

But then again I change my mind, thinking that the impulse [to join addressee Ioannes Xiphilinos again at Olympos] might not be divine, and regret might follow the action.[10]

Here Logion suggests a change from πω to πως, which we believe to be correct; μή πως is a standard idiom in fear clauses (here implied)

[9] E.g., understanding "obscurely" (ἀμυδρῶς, 56) versus seeing "more keenly" (ὀξύτερον, 64), proclaiming "brightly and purely" (λαμπρῶς τε καὶ καθαρῶς, 108-9), darkness versus the "brightness of truth" (τὸ τῆς ἀληθείας ὑπέρλαμπρον, contrasting σκότος, 140-1), "easily taken in by sight" (εὐσύνοπτος, 267), "making visible" (δηλόω, 275, 448; ἀρίδηλος, 391; προδήλως, 418). For forms of σαφής, Westerink and Duffy cite 258-9 and 670; we also note instances at 380 and 406.

[10] For biographical context, see Kaldellis and Polemis 2015: 23-6 (though contrast Jeffreys 2016: 258, who dates the letter prior to Psellos' time at Olympos).

and appears elsewhere in Psellos, while we find no uses of μή πω in such a construction in Psellos. In this case, too, Logion is not the first to suggest this emendation; rather, it was anticipated by Diamantopoulos' emendation μήπως, published in his review of Kurtz and Drexl's 1941 edition.[11] If we follow these changes, we can trace a circuitous path of editorial emendation and restoration: μήπω in the manuscript (Oxford, Bodleian Library, Barocci 131) is replicated as μή πω by Kurtz and Drexl, emended to μήπως by Diamantopoulos, restored to μή πω by Papaioannou, and finally re-emended to μή πως by Logion.

A flag like this might seem useless, since it does not offer new information or provide new arguments for the adoption of specific readings. However, observing the intersection between editorial history and machine emendation can have the benefit of reminding us that tools like Logion do not have to represent a rupture in philological practice, that we can also choose to focus on continuities. In fact, evaluating one of Logion's suggestions is a process very similar to evaluating another editor's conjecture (or a manuscript variant), and when Logion's suggestion actually *is* an earlier editor's conjecture, in this case Diamantopoulos', this becomes especially clear. Nor is a machine-generated suggestion, even with a philologist's endorsement, the final word on a textual problem. Rather, once adopted, it remains subject to the same challenges and reconsiderations that any variant or emendation faces as philologists continue to grapple with the text in reviews and critical editions.

Our last example in this section is the least philologically useful, but still expands our field of vision when it comes to assessing the history of emendation and how machine-learning tools like Logion may fit within this history. At *Poem*. 8.549-50, Westerink prints:

τυχὸν γὰρ ἔμελλέ τις πλεῖν πλοῦν ἐπικινδυνώδη
καὶ δέδωκέ **τῳ** χρήματα τῷ φόβῳ τοῦ θανάτου·

For perhaps someone was about to undertake a dangerous voyage
and gave his possessions to someone out of fear of death.

Logion flags τῳ as an error and proposes the replacement τὰ. The flag is incorrect; δέδωκε requires an indirect object here, and while τὰ for τῳ is plausible, Westerink's text is better (and better attest-

[11] Diamantopoulos 1941: 304.

ed), especially as τῳ is a relatively rare form and therefore the *lectio difficilior*. Such suggestions from Logion are frequent because of the machine's current setup: texts are inputted without diacritics, making the alternative genitive and dative forms of τις (του, τῳ) indistinguishable from the article. But interestingly, we can see Logion's error mimicked in one of our Class 3 manuscripts, Paris, Bibliothèque nationale de France, Grec 478, which also changes τῳ into the accusative plural article. According to Westerink (1992: XIX), this manuscript features a number of emendations absent from others of the same family, suggesting the work of an overeager scribe. It is unclear to us, in this instance, whether the scribe intentionally emended τῳ or simply erred in his transcription. Regardless, the error is an interesting mark of continuity across centuries and between the kinds of mistakes humans and machines make. It may also suggest that the same healthy skepticism that grounds our assessment of manuscript variants can productively shape our treatment of machine-produced emendations.

3. *Making the Most of a Flawed Machine Suggestion*

So far, our examples have primarily featured flags that improve the text. But, as our last example shows, not all of Logion's suggestions lead to improvements. Many are plainly wrong; others seem unnecessary, impossible, or frankly baffling. And yet even an incorrect suggestion can yield results that are productive, especially when paired with (human) philological investigation. This is the case at *Or. hag.* 8.675-79, where Fisher prints the following text:

ἀλλὰ σὺ τῷ φίλτρῳ γε καὶ τῇ πίστει καὶ μόνοις προσέχοις (ὁπόσον γὰρ ἀποδεῖ τὰ τοῦ λόγου, ἐπὶ πλέον τὰ τῆς στοργῆς ὑπερτερεῖ καὶ ὑπέρκειται· **αἱρέσει** δὲ καὶ οὐχὶ ὄγκῳ τὰ προσαγόμενα κρίνεται)

But may you also attend to love and faith alone (for however much reason falls short, love surpasses and transcends this by far; for offerings are judged according to intention, not amount).

Logion marks αἱρέσει as an error and suggests instead ἀφαιρέσει, albeit with low confidence. At first glance, we were puzzled by the suggestion, which makes little sense in the context of the passage. A TLG

search, however, reveals a closely related passage in John Chrysostom (*Ad. Jud.* PG 48.853 Migne):[12]

ἀλλ' οὐ τῇ φύσει τῶν δώρων, ἀλλὰ **τῇ προαιρέσει τῶν προσαγόντων προσέχων ὁ Θεός**, οὕτω **κρίνει τὰς προσφοράς**.

Attending not to the nature of the gifts, but to the intention of the givers, does God judge offerings.

A related argument appears in a second homily, where Chrysostom compares Peter's sacrifice to follow Jesus to that of the poor widow of Luke 21:1-4 and Mark 12:41-44 (*Hoc Scitote* PG 56.275 Migne):

καὶ γὰρ ἡ τὰ δύο καταβαλοῦσα δηνάρια **οὐ πολὺν ὄγκον** κατέθηκε χρημάτων, ἀλλὰ **πολὺν πλοῦτον ἐπεδείξατο προαιρέσεως**, καθάπερ καὶ οὗτος ἐν πολλῇ πενίᾳ μεγάλην εὐπορίαν προθυμίας παρέσχετο.

For the woman who put down two denarii did not give a great amount of money, but showed great wealth of intention, just as [Peter] too, amidst much poverty, offered great abundance of goodwill.

Here we see the juxtaposition of quantity with intention, the same dichotomy that appears in our *Or. hag.* 8 passage, though in this case without the element of divine judgment. While the phrasing in *Or. hag.* 8 aligns most closely with that of John Chrysostom, the concept of judging by intention ultimately derives from Aristotle, who argues that it is by intention (προαίρεσις), rather than action, that we can best judge excellence or wickedness of character (*Eth. Eud.* 1228a; *Eth. Nic.* 1111b). The argument has an afterlife elsewhere in Byzantine literature as well,

[12] Similar arguments appear at *Ad. Jud.* PG 48.902 Migne (*καθαρὰν* δὲ λέγει θυσίαν, ὡς τῆς προτέρας ἀκαθάρτου οὔσης, οὐ διὰ τὴν οἰκείαν φύσιν, ἀλλὰ **διὰ τὴν προαίρεσιν τῶν προσαγόντων**); *In Gen.* PG 53.243 Migne (ἄκουε τοῦ προφήτου λέγοντος, *Θυμίαμα εἰς βδέλυγμά μοι ἐστὶ*, μονονουχὶ δεικνύοντος **τῆς προαιρέσεως τῶν προσαγόντων** τὴν μοχθηρίαν). Judgment according to intention (though not in reference to gifts or offerings) appears frequently in Chrysostom; see e.g., *De Sac.* 4.6.48-9 Malingrey; *De Sanctis Bernice et Prosdoce* PG 50.632.8-9 Migne; *In Matt.* PG 57.87.51-3 Migne.

including in Psellos.[13] Whatever our author's direct source, he adapts it to the context of a closing prayer, asking God to judge his followers by their faith and love, rather than their wisdom (or lack thereof), and by the intention rather than the quantity (ὄγκος) of their offerings.

But what about the flag itself? Why does Logion suggest ἀφαιρέσει? As we have seen, Aristotle and writers following in his tradition, including John Chrysostom, use forms of προαίρεσις where the manuscript of *Or. hag.* 8 has αἵρεσις. We therefore believe that **προ**αιρέσει, rather than αἱρέσει, is the correct reading for our text as well. With the caveat that we cannot know on what basis Logion makes a specific suggestion, it seems probable that it registers the lack of the prefix προ- in αἵρεσις as a divergence from the known pattern of Chrysostom and Aristotle and restores a prefix to resolve this. However, it suggests the wrong prefix, ἀφ- rather than προ-, resulting in ἀφαιρέσει, which is nonsensical in context. The point here is that while Logion does not solve this textual problem, its suggestion is still helpful. In other words, even an incorrect flag can draw our attention to a problematic passage and provide clues to its resolution. Without the flag, we may not have thought to read the passage intertextually, or to look more carefully at αἱρέσει. That said, Logion is useless without human interpretation, and it is the human philologist who will make connections across texts, evaluate grammatical and stylistic probabilities, and use Logion's suggestions as a jumping-off point for different solutions. Machine learning can assist in the emendation of texts, but only philologists can choose the best reading.

4. *Old Problems, New Perspectives*

Our final example offers us little philological clarity, but in spite or perhaps because of this, can help us reflect upon the ability of machines like Logion to show familiar problems from new angles. At *Psych.* p. 42.8-11, O'Meara prints:

εἰ κινεῖται ὑπὸ τῶν αἰσθητῶν, οὕτως ὥσπερ, εἴ **τις** ὑπνοῦντα γεωμέτρην ἔξυπνον {τις} ἐποίησε, γρήγορσιν μὲν τούτῳ ἐποίησεν, οὐ μὴν δ' ἐνέβαλε καὶ τὰ θεωρήματα τούτῳ.

[13] *De Omn. Doct.* 63.

If [the soul] is moved by perceptible things, it is just as if someone wakes up a sleeping geometer: he causes wakefulness in the man, but does not also put theorems in him.

A problem clearly lies in the recurrence of τις. O'Meara resolves this by removing the second τις, perhaps because εἴ τις seems a more natural construction than εἰ ... τις ἐποίησε, or on the assumption that the scribe forgot he had already written τις by the time he reached ἐποίησε. This is a plausible solution, and it should be noted that it is the kind of solution that Logion cannot provide: in its current setup, Logion is unable to delete a word but can only replace one word with another (though this may change in the future). In the present case, Logion flags the first τις as an error and suggests τὸν with fairly high confidence. At first glance, the article before ὑπνοῦντα γεωμέτρην seems redundant or even mistaken. We can glean further insight, however, through comparison to Psellos' known source here, a passage from Joannes Philoponos' commentary on Aristotle's *De Anima* (CAG 15.110.27-34 Hayduck):

ἀλλὰ λέγομεν πρὸς τοῦτο ὅτι εἰ καὶ κινεῖται ἡ ψυχὴ ὑπὸ τῶν αἰσθητῶν, ἀλλ' οὖν οὕτω κινεῖται, ὥσπερ **ὁ** καθεύδων γεωμέτρης ὑπὸ **τοῦ** ἐξυπνίσαντος. ὥσπερ οὖν **ὁ** ἐκεῖνον ἐξυπνίσας τοσοῦτον μόνον τὸ ἐμποδίζον ἐξεῖλε, τὰ μέντοι θεωρήματα τὰ γεωμετρικὰ οὐκ ἐνέβαλε τῷ γεωμέτρῃ, οὕτω καὶ ἡ ψυχὴ ἔχουσα τοὺς λόγους τῶν πραγμάτων ἐν ἑαυτῇ καὶ ὥσπερ ὑπὸ τοῦ ὕπνου τῆς γενέσεως ἀνενέργητος οὖσα ὑπὸ τῶν αἰσθητῶν ἐρεθιζομένη ἢ τῶν διδασκάλων προχειρίζεται τοὺς ἐν αὑτῇ λόγους·

But we say to this that even if the soul is moved by perceptible things, it is moved like the sleeping geometer by the man who woke him up. Just as the man who woke him only removed a hindrance to a certain extent, but did not put geometrical theorems in the geometer, thus too the soul, which possesses knowledge of things in itself and has become inactive as though from the sleep of becoming, when provoked by perceptible things or by its teachers, mobilizes the knowledge in itself.

Philoponos in turn draws on a passage in Aristotle's *De Generatione Animalium* (735a Drossaart Lulofs):

ἐγγυτέρω δὲ καὶ πορρωτέρω αὐτὸ αὑτοῦ ἐνδέχεται εἶναι δυνάμει, ὥσπερ **ὁ** καθεύδων γεωμέτρης **τοῦ** ἐγρηγορότος πορρωτέρω καὶ οὗτος τοῦ θεωροῦντος.

It [the semen] may be nearer or further from itself in potential, as the sleeping geometer is further [from his realization in actuality] than the geometer who is awake, and the geometer who is awake is further than the one who is theorizing.

In both Philoponos and Aristotle, as noted in bold, both the geometer (**ὁ** καθεύδων γεωμέτρης) and the man waking him (**τοῦ** ἐξυπνίσαντος / **ὁ** ἐκεῖνον ἐξυπνίσας / **τοῦ** ἐγρηγορότος) are treated with a preceding article.[14] Since Psellos adopts the Philoponos passage fairly closely, τὸν is a more plausible replacement for the first τις than we may initially have thought. But since Psellos replaces the article modifying the man waking the geometer with τις, it is perhaps even better to emend the first transmitted τις to τιν', to produce εἴ **τιν'** ὑπνοῦντα γεωμέτρην. Admittedly, εἴ τινα ... τις is a less natural construction than εἴ τις, but it does appear occasionally, especially when τινα is followed by other accusatives.[15]

All of this leaves us with three possible solutions, but no definite emendation. O'Meara's deletion of the second τις can certainly be defended, but it is also a simple answer to what may be a more complicated problem. The benefit of Logion here is that it encourages us to think in different directions: not just left to right, like a scribe copying a text fairly mechanically, but also right to left and across texts. One interesting aspect of its calculations, for instance, is the fact that the machine considers the probability of each τις separately: that is, while a human philologist looks at the two words in tandem, Logion evaluates the likelihood of each on its own, *on the assumption that the other τις is correct*. On its face, that might seem a disadvantage, and in some instances it can be, but in this particular case, it forces a reevaluation of O'Meara's solution by offering plausible, if more difficult, alternatives. As always, the true work of philology is up to the human philologist: Logion will never quote important intertexts or evaluate the kinds of scribal error most likely to appear in a particular manuscript. But by

[14] We follow Hayduck in his reading of **ὁ** ἐκεῖνον ἐξυπνίσας, though there are manuscript discrepancies. Victor Trincavellus' *editio princeps* (t) and the first hand of D (Paris, Bibliothèque nationale de France, Grec 1914) omit ὁ here; a second contemporary hand (D^2) adds ὁ to D, and R (Milano, Biblioteca Ambrosiana, L 106 sup.) also includes ὁ.

[15] See, e.g., Paus. *Graec. Desc.* 4.21.4.

taking Logion's flags as a starting point, the philologist can also discover new textual problems and unexpected solutions or insights.

Conclusion: Change and Continuity in Philological Practice

In this chapter, we hope to have shown the possibilities of working with a machine like Logion – as well as the challenges that accompany this and indeed every philological endeavor. Working with Logion, in our experience, entails not a turning away from traditional philology, but a reconsideration of how we make and have historically made philological decisions, from emendation by intuition to the modern editor's TLG search. Using Logion responsibly requires a consciousness of our own methods and their biases, as well as those of the machine. Logion "makes decisions" differently from philologists – for now without manuscript variants or access to full critical editions, and in any case without semantic understanding – and it is this difference that both enables it to shake up our thought processes and determines its limits as a philological tool.

We have titled this chapter *Machines, Scribes, and Scholars* not just as a nod to Reynolds and Wilson's famous book, but also to signal an awareness of the many human hands by which ancient texts have been treasured, edited, and passed down. Introducing machine learning into this tradition is no small matter.[16] At the same time, Logion is a tool that enables philology; it does not replace it, but rather offers new textual problems and possibilities that both demand and spur human ingenuity. Sophus Helle argues that philology starts from "crises of reading", that it is "the result of an inability to read a given text, combined with a refusal to turn away from it in incomprehension".[17] Textual problems will remain a site of human pleasure, vexation, and uncertainty, whether the problem is found in a manuscript, an apparatus criticus, or a machine-generated error report.[18] And while it would

[16] On the ethical dilemmas of machine learning in philology, see e.g. Graziosi et al. 2023: 277-80.

[17] Helle 2022: 616.

[18] Drawing from Helle's compelling comparison of the philologist to Bundgaard's *Granskende pige* (*Scrutinizing Girl*, 1934) and discussion of philology "as textual desire", "the love of lore", which is inevitably accompanied by frustration (2022: 616, 619).

be naive to suggest that machine learning will not change philology, we should also have confidence in the longevity of what grounds our field: curiosity, ingenuity, diligence, and a love for texts.

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Olivia May and Leyla Ozbek

This volume presents the results of a collaboration between researchers at the Scuola Normale Superiore, Pisa, and Princeton University. It introduces readers to Logion, the first deep neural network designed to support philologists in editing Greek texts that have reached us via manuscript transmission. The model offers suggestions for how to fill lacunae; it also helps identify and emend portions of text that seem to have been corrupted in the process of textual transmission. The different chapters explore the theory and historical practice of philology, present the AI model we designed, and make use of Logion in elucidating passages of premodern Greek. The focus is on the vast corpus of the Byzantine polymath Michael Psellos, which represents an excellent case study, from both a philological and technical perspective. Overall, the aim of this volume is both practical and intellectual. It seeks to encourage a broader dialogue between artificial intelligence and Greek philology and to present an actual model for the use of machine learning in elucidating premodern texts.