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E A INOVAÇÃO**

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HOW INSIGHTS FROM THE HUMANITIES SHAPED THE TWENTIETH CENTURY

ABSTRACT

What have the humanities brought us during the last century? Once the pinnacle of intellectual fulfillment, today the humanities suffer from an image problem. Disciplines like philology, art history, linguistics and musicology are seen as a luxury pastime which is of little use to society and less to the economy. Arguments in favour of the humanities emphasize their importance for critical thinking, historical responsibility and for creating competent democratic citizens. While these arguments may all be true, humanities scholars seem to overlook the possibility that the very assumption behind the image problem is wrong. Many scholars stress that the humanities do not solve concrete problems and that their value lies elsewhere. Yet a closer look at the history of the humanities shows a rather different picture. In my talk I will focus on the comparative history of the humanities during the long twentieth century. I will show how ideas and concepts from linguistics have led to the development of high-level programming languages in computer science. I will argue that methods from philology were incorporated by biology to analyze DNA sequences. And I will describe how the method of historical source criticism found its way into other disciplines for critically evaluating sources: from forensic science to evidence-based medicine and jurisprudence.

¹ I wish to express my thanks to the Faculty of Arts and Humanities of the University of Porto for inviting me to deliver a keynote lecture at the celebrative conference of their hundred year existence. Some ideas in this paper were previously published in Rens Bod - A Comparative Framework for Studying the History of Humanities and Science. *Isis*, 106:2 (2015) 367-377.

RESUMO

O que é que as Humanidades nos trouxeram no decurso do século passado? Antigamente o suprassumo da realização intelectual, hoje em dia as Humanidades estão a sofrer uma crise de imagem. Disciplinas como a filologia, a história de arte, a linguística e a musicologia são consideradas passatempos de luxo sem muita utilidade para a sociedade e muito menos para a economia. Os argumentos a favor das Humanidades realçam a sua importância para o desenvolvimento do pensamento crítico e da responsabilidade histórica, bem como para garantir a formação de cidadãos competentes e democráticos. Muito embora estes argumentos sejam verdadeiros, os académicos desta área parecem descurar a hipótese que o próprio pressuposto subjacente à crise de imagem das Humanidades seja errado. Muitos académicos sublinham o facto de que as Humanidades não resolvem problemas concretos e que o seu verdadeiro valor é outro. Todavia, uma análise mais aprofundada da história das Humanidades revela um panorama substancialmente diferente. Na presente comunicação, irei debruçar-me sobre a história comparativa das Humanidades durante todo o século XX, demonstrando como ideias e conceitos surgidos no âmbito da Linguística conduziram ao desenvolvimento de linguagens de programação de alto nível na Informática. Defenderei também que os métodos da Filologia foram incorporados pela Biologia e utilizados para a análise de sequências do ADN. Por fim, debruçar-me-ei sobre a forma como o método da crítica das fontes históricas foi adotado por disciplinas como as Ciências Forenses, a Medicina baseada na evidência ou a Jurisprudência como instrumento de análise crítica das fontes.

INTRODUCTION

There is a preconception so deeply rooted in our culture that even scholars seem to believe it. This is the assumption that whatever humanities scholars do, they do not solve societal problems and neither does their research result in technological applications². Yet a quick glance at the general history of

² Examples of this preconception can be found in almost any discussion on the humanities, including Martha Nussbaum, *Not for profit: why democracy needs the Humanities*, Princeton University Press, 2010; Jörg-Dieter Gauger and Günther Rüter (ed.), *Warum die Geisteswissenschaften Zukunft haben!*, Herder, 2007; Stanley Fish, Will the Humanities Save Us?, *New York Times*, January 6, 2008. Jonathan Bate (ed.), *The Public value of the Humanities*, Bloomsbury Academic, 2010. For a historical overview, see Helen Small, *The Value of the Humanities*, Oxford University Press, 2013.

the humanities³ shows otherwise: contrary to common wisdom, insights and methods from the humanities solved concrete problems and resulted in applications that had a profound impact on society. To be sure, such utilizations of humanistic insights and methods sometimes emerged after considerable time. But methods and theories from the humanities have been picked up and used in a large variety of other disciplines.

In the following I will review some of the far-reaching effects of humanistic inquiry and discuss their influence on society and science. It is surprising that overviews of the history of science have left out the impact received from the humanities⁴. This essay opts for an inclusive history of knowledge where the sciences and the humanities are discussed on a par⁵.

There is a question what we mean by the ‘humanities’. While we usually know what is meant by the ‘sciences’, we are left empty-handed when asked for a definition of the humanities. As a working definition for this essay, I shall refer to the humanities as “the disciplines that investigate the products of the human mind”⁶. Thus disciplines like linguistics, art history, literary studies, musicology, theatre studies, film studies, history and philology are all humanistic disciplines, as well as many others.

LINGUISTICS AND THE IMPACT OF GRAMMAR

One of the most salient technological developments during the last century has been the emergence of information technology. While this development is not usually seen as a product of the humanities, it was a humanistic discipline – the study of language – that made information technology possible. A fundamental insight in linguistics is that language can be described by a

³ See e. g. Rens Bod, *A New history of the Humanities: the search for principles and patterns from Antiquity to the present* (Oxford: Oxford University Press, 2013); James Turner, *Philology: the hidden origins of the modern Humanities* (Princeton: Princeton University Press, 2014). See also the three edited volumes on the comparative history of the humanities: R. Bod, J. Maat and T. Weststeijn (ed.), *The Making of the Humanities, Vol. I: Early Modern Europe*, Amsterdam University Press, 2010; R. Bod, J. Maat and T. Weststeijn (ed.), *The Making of the Humanities, Vol. II: From early modern to modern disciplines*, Amsterdam University Press, 2012; R. Bod, J. Maat and T. Weststeijn (ed.), *The Making of the Humanities, Vol. III: The Modern Humanities*, Amsterdam University Press, 2014.

⁴ This is not the place to summarize the historiography of science, but overviews of the history of science are as old as the field itself and continue to be written up to the current day. They include William Whewell, *History of the Inductive Sciences*, 3 volumes, Parker, 1837; George Sarton, *Introduction to the History of Science*, 3 volumes, Williams and Wilkins, 1931-1947; Stephen Mason, *A History of the Sciences*, Macmillan, 1962; William Dampier, *A History of Science and its relation to Philosophy and Religion*, Cambridge University Press, 1966; James McClellan and Harold Dorn, *Science and Technology in World History*, Johns Hopkins University Press, 1999; Frederick Gregory, *Natural Science in Western History*, Wadsworth Publishing, 2007; Patricia Fara, *Science: A Four Thousand Year History*, Oxford University Press, 2009.

⁵ See Rens Bod, *Een Wereld Vol Patronen: De Geschiedenis van Kennis*, (A World of Patterns: the History of Knowledge), Prometheus, 2019 (in Dutch, to appear in English in 2021).

⁶ Wilhelm Dilthey, *Einleitung in die Geisteswissenschaften: Versuch einer Grundlegung für das Studium der Gesellschaft und der Geschichte*, 1883, p. 11f.

system of rules, known as a *grammar*. The concept of grammar is older than the first systematic Greek descriptions of language. The first extant grammar is found in the work *Ashtadhyayi* (Eight Books) by the Indian grammarian Panini⁷ who lived around 500 BC⁸. The *Ashtadhyayi* contains one of the most complete grammars in existence⁹. Panini developed a set of 3,959 rules that covers all possible sentences of Sanskrit. That is, Panini's grammar can determine whether a given sequence of sounds is a correctly formed sentence in Sanskrit. Panini's grammar is still unsurpassed¹⁰. After two and a half thousand years, the efficacy of this system of nearly four thousand complex interconnected rules remains undisputed.

Panini was not just a descriptive linguist, however; the underlying formalism he developed is just as interesting. To write down his 3,959 rules, he used a grammatical system that is nowadays known as *rewrite grammar*¹¹. His rewrite grammar consists of rules that indicate how a certain part of a sentence (a 'phrase') can be built up ('rewritten') out of other, smaller phrases and words, provided they appear in a certain combination. In fact not every combination of words or phrases leads to a grammatical sentence. For example, in English there is a rule that states that a nominal phrase can consist of an article and a noun, as in 'the house'. Clearly, these words only form a correct phrase if the article appears before the noun.

Panini's approach in the *Ashtadhyayi* was to make his grammar system explicit and comprehensive. He devised a set of rules that, using a combination of a finite number of lexical units (the *word stems*), could cover all correct Sanskrit utterances¹². Panini invented an ordered system of rules in order to achieve this goal. His rules are applied in a certain order so as to arrive at a linguistic utterance. This corresponds to the concept of an algorithm: a procedure that generates a result in a finite number of sequential steps. Panini's rules are also *optional*¹³, which means there is always more than one possible choice (otherwise it would only be possible to cover one linguistic utterance). He introduced a metarule in order to make his system consistent: 'If two rules conflict, the last rule prevails'¹⁴. Panini organized his grammar so that this metarule is always valid.

⁷ The transcription from Sanskrit by Indologists is usually Pāṇini, where the accent is on the first syllable ('Pā'). For this paper I will use the more common transcription Panini.

⁸ Paul Kiparsky, 'Paninian Linguistics', in *The Encyclopedia of Language and Linguistics* (Amsterdam: Elsevier, 1993).

⁹ For an accessible translation of the *Ashtadhyayi*, with examples and commentaries, see Panini, *The Ashtadhyayi -- Translated into English by Srisa Chandra Vasu* (1923; repr., Charleston: Nabu Press 2011).

¹⁰ Esa Itkonen, *Universal History of Linguistics* (Amsterdam and Philadelphia: Benjamins, 1991), 12ff.

¹¹ Frits Staal, *Universals: studies in Indian Logic and Linguistics* (Chicago: University of Chicago Press, 1988), 3.

¹² Vidyaniwas Misra, *The Descriptive technique of Panini: an introduction*, Mouton, 1966, p. 43f.

¹³ Panini's rule 2.1.11 (*vibhasa*) in the *Ashtadhyayi*.

¹⁴ Panini's rule 1.4.2 in the *Ashtadhyayi*.

One of the other influential ideas in Panini's system of rules is that a grammar rule can invoke itself – a given construction can contain another example of that construction. This is known as recursion, in Sanskrit known as *Nyāya*. Recursion occurs for example in the English sentence, 'He was harassed by the individual who was caught by the policeman who was spotted by the photographer'. We can make this sentence longer, indeed as long as we want, by recursively applying the grammatical rule for subordinate clauses in English (and by choosing different words from the lexicon). The use of recursion allowed Panini to describe the unlimited number of Sanskrit sentences with a finite number of rules.

The invention of a precise system of grammar rules together with the concept of recursion makes Panini the most original linguist of antiquity. His grammar is regarded as a major monument in human thought¹⁵. Only towards the end of the eighteenth century was Panini's grammar discovered by European scholars, and it took another century and a half before it was relatively well understood. In the 1950s, the renowned linguist Noam Chomsky based his work on Panini's ideas and called him his spiritual father¹⁶. Yet it is still an open question whether a finite system of rules can represent a 'complete' grammar of a living language¹⁷ – only for a dead language like Sanskrit does this seem to be beyond doubt.

Nevertheless, the notion of grammar appeared to be exceptionally well suited for describing – and creating – a rather different kind of language: high-level programming languages for computers. In contrast with low-level programming languages, high-level programming languages do not use zeroes and ones or other machine-like codes for programming. Instead they use statements that resemble sentences and phrases in human languages, including recursive structures (which are only in a second stage translated into the underlying machine language and finally into zeroes and ones by a separate algorithm). It was Panini's formalism of grammar with recursion that came to be applied by John Backus to design the full syntax of the first high-level programming language *ALGOL60*. The resulting formalism is also referred to as the Panini-Backus form¹⁸. Virtually all current high-level programming languages are written in a formalism that incorporates the linguistic notion of a grammar with recursion¹⁹. Such a grammar determines whether a given sequence of statements forms a correct expression in a

¹⁵ Leonard Bloomfield, *Language* (1933; repr., Chicago: University of Chicago Press, 1984), 11.

¹⁶ For a discussion of the relation between Panini and Chomsky, see Bod, *A New History of the Humanities*, 290–295.

¹⁷ See Rens Bod, *Beyond Grammar* (Chicago: University of Chicago Press, 1998).

¹⁸ P. Z. Ingerman, 'Panini-Backus Form Suggested', *Communications of the ACM*, 10:3 (1967) 137.

¹⁹ See Erol Gelenbe and Jean-Pierre Kahane (ed.), *Fundamental Concepts in Computer Science*, Imperial College Press, 2009, p. 99.

particular programming language. If the statements follow the rules of the grammar, they are correct, which means that they can be processed by the underlying machine language.

The linguistic formalism of rewrite grammar was taken over and reused by computer scientists giving the field of computer science and information technology an unprecedented impulse. In the history of computer science, the linguistic invention of a rewrite grammar plays a key role²⁰.

PHILOLOGY AND THE BIOLOGICAL APPROPRIATION OF TEXTUAL TECHNIQUES

Concepts and methods from the language sciences also found their way in the life sciences. In the course of the 1950s, biologists came to represent organisms and molecules as information systems by using linguistic tropes and textual analogies²¹. The human genome was viewed as a textual information system: the way DNA sequences could be replicated, mutated and contaminated were phrased in terms of philological and computational concepts. These representations of heredity did not arise from the inner logic of DNA genetics. Instead, they had been transported into molecular biology from cybernetics, information theory and computer science²² who in turn had imported these metaphors from the language sciences, as we discussed above²³. But while computer scientists had looked mainly at linguistics, molecular biologists (also) looked at stemmatic philology – the theory of text reconstruction that creates a tree of variants (a stemma) of the transmission of a text so as to deduce its presumed archetype.

The way biologists made use of textual concepts in DNA genetics was not just a matter of metaphor or analogy. If we look at the deeper level of formalisms used in philology and DNA genetics, we can discern an equivalence between 19th-century stemmatic philology and 20th-century molecular biology. This equivalence went even further than the one discussed between linguistics and computer science: not only was the formalism of a philological tree of texts (or stemma) taken over by biologists but also several of the rules or operations that philologists had developed to operate on a stemma.

²⁰ See Edwin Reilly, *Milestones in Computer Science and Information Technology*, Greenwood Publishing Group, 2003, p. 43f; Martin Davis, Ron Sigal, and Elaine Weyuker, *Computability, Complexity, and Languages: Fundamentals of Theoretical Computer Science*. Academic Press, Harcourt, Brace, 1994, p. 327.

²¹ See Henry Hoenigswald and Linda Wiener, *Biological metaphor and cladistic classification: an interdisciplinary perspective*, University of Pennsylvania Press, 1987. See also Lily Kay, *Who Wrote the Book of Life?: A History of the Genetic Code*, Stanford University Press, 2000, p. 2-3.

²² Steve J. Heims, *The Cybernetics Group*, MIT Press, 1991; Lily Kay, "Cybernetics, Information, Life: The Emergence of Scriptural Representations of Heredity", *Configurations* 5:1 (1997) 23-91.

²³ The prime example in information theory was language – see Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication*, University of Illinois Press, 1949.

The history of the notion of stemma has been investigated at various places. Robert O'Hara draws attention to the presence of "trees of history" glossed as "branching diagrams of genealogical descent and change" in a large variety of disciplines: textual criticism, evolutionary biology, historical linguistics and information science²⁴. The first ever stemma seems to have been produced for Swedish legal manuscripts by Carl Johan Schlyter in 1827²⁵. It predates the use of the first genealogical trees in linguistics by August Schleicher in 1850 and evolutionary biology by Charles Darwin in 1859. It was the philologist Karl Lachmann (1793–1851) who in 1850 spelled out the rules that applied to a philological stemma of texts and how they could be used in reconstructing the original text from hereditary copies in the family tree²⁶. While the origins of this technique of text reconstruction are much older – it can be traced back to the early humanists, in particular to Angelo Poliziano²⁷ – only in the nineteenth century this humanistic practice was turned into a more or less orderly set of rules. These rules were further refined and mathematically formalized in the early twentieth century²⁸, which resulted in several formal rules or operations for describing the 'errors' in variants due to copying mistakes, such as rules for *substitution*, *deletion* and *insertion* of elements²⁹.

These operations of substitution, insertion and deletion turned out to be applicable both to sequences of lexical elements and to sequences of DNA elements – thus independent of whether these elements were due to *scribal alterations* arising over successive generations of recopied manuscripts or due to *genetic mutations* in DNA molecules occurring through successive generations³⁰. At the level of the formalism used and (several of the) operations applied, there is not just analogy but equivalence between philology and

²⁴ Robert O'Hara and Peter Robinson, "Computer-Assisted Methods of Stemmatic Analysis", *Occasional Papers of the Canterbury Tales Project*, 1, 1993

²⁵ Schlyter's stemma was added in the appendix (ill. 2) of Carl Johan Schlyter and Hans Samuel Collin (ed.) 1827. *Västgöta-lagen*, vol.1, Håggström, 1827. See also Britta Olrik Frederiksen, "Stemmaet fra 1827 over Västgötalagen – en videnskabshistorisk bedrift og dens mulig forudsætninger." *Arkiv för nordisk filologi*, 124 (2009) 129-150.

²⁶ Sebastiano Timpanaro, *La Genesi del metodo del Lachmann*, Liviana, 2nd ed., 1981, p. 5-13. Translation by Glenn Most, *The Genesis of Lachmann's Method*, University of Chicago Press, 2005.

²⁷ Angelo Poliziano, *Miscellanea*, 1489. For the origins of formal text reconstruction, see Anthony Grafton, *Defenders of the Text* (Cambridge, MA: Harvard University Press, 1991), 56f. See also See Glenn Most, "Quellenforschung", in R. Bod, J. Maat and T. Weststeijn (ed.), *The Making of the Humanities, Vol. III: The Modern Humanities*, Amsterdam University Press, 2014, p. 207-218.

²⁸ See Walter Greg, *The Calculus of Variants: an essay on textual criticism* (Oxford: Oxford University Press, 1927); For an overview, see Vinton Dearing, *Principles and practice of textual analysis* (Berkeley: University of California Press, 1974).

²⁹ For a history of these copying rules in stemmatic philology, see Kari Kraus, "Conjectural Criticism: Computing Past and Future Texts", *Digital Humanities Quarterly*, 3:4 (2009) (no page numbers).

³⁰ See Willi Hennig, *Phylogenetic Systematics*, University of Illinois Press, 1966.

genetics!³¹ That is, both in philology and genetics a sequence (be they words in the case of a manuscript, or nucleotides in the case of DNA) is copied on the basis of the same operations. When changes occur, textual changes and DNA mutations are described by the same system of rules or operations. For example, the operation of substitution of one word for another (in text copying) is equal to the substitution of a nucleotide for another (in DNA copying). The elements differ, but the abstract rule or operation is the same. And the operation of insertion or deletion of words is formally equal to the rule of insertion and deletion of nucleotides. Even philological contamination, whereby pieces from several manuscripts are combined, follows the same formal rule in DNA genetics, known as genetic recombination³².

Thus the formalism and rule system from the discipline of textual philology were decontextualized and next recontextualized in the new field of genetics. We cannot really grasp the history of science, in this case 20th-century genetics, if we neglect the long-term history of its methods some of which originate in the humanities, in this case 19th-century stemmatic philology. But the opposite also holds. In fact, the story does not finish here. Over the last few decades, stemmatics in biology has led to the new field of *cladistics* which has turned into a highly sophisticated computer-assisted methodology for creating history trees in biology. Although originating in philology, cladistics has now influenced philology and historical linguistics again, not only technically but also conceptually³³. Cladistic software is currently applied to stemmatic philology to derive highly sophisticated trees of texts that lead to new questions in philology³⁴. Thus the interaction between humanistic and scientific disciplines is a highly dynamic one; it is rarely a one-way transfer: formalisms and rule systems from philology first entered in biology and next came back to philology in computational form. The same happened with linguistics and computer science: the linguistic notion of grammar was first transferred to computer science, from which the notion of computational grammar came back to linguistics, leading to the field of computational linguistics.

³¹ See Don Cameron, "Problems in Manuscript Affiliation", in Hoenigswald, Henry, and Linda F. Wiener, *Biological metaphor and Cladistic classification: an interdisciplinary perspective*, University of Pennsylvania Press, 1987, p. 302.

³² See Kari Kraus, *ibidem*, 2009. See also Caroline Macé, Philippe Baret, Andrea Bozzi and Laura Cignoni, (eds.), "The Evolution of Texts: Confronting Stemmatological and Genetical Methods", *Proceedings of the International Workshop held in Louvain-la-Neuve on September 1–2, 2004*, Istituti Editoriali e Poligrafici Internazionali, 2006.

³³ See N. Platnick and H. Cameron, "Cladistic methods in textual, linguistic, and phylogenetic analysis", *Systematic Zoology*, 26 (1977) p. 380-385. For an overview of cladistics and other methods in philology, see Macé *et al.*, *ibidem*, 2006.

³⁴ See *e. g.* N. Cartlidge, "The Canterbury Tales and cladistics", *Neuphilologische Mitteilungen*, 102 (2001) 135-150; Heather Windram, Prue Shaw, Peter Robinson and Christopher Howe, "Dante's *Monarchia* as a test case for the use of phylogenetic methods in stemmatic analysis", *Literary and Linguistic Computing*, 23 (2008) 443-463.

THE ASTONISHING EFFECTS OF HISTORICAL SOURCE CRITICISM

One might object that linguistics and stemmatic philology, with their formalized methods, do rather belong to the sciences than to the humanities – it is actually the historical disciplines that are the real backbone of humanistic research. Historiography, as the German philosopher Wilhelm Dilthey put it, is not concerned with explaining events but with understanding them, as illustrated by the German word *verstehen*³⁵. In the view of the Neo-Kantians, rather than aiming at finding general rules or regularities (nomothetic), as linguistics and stemmatic philology do, historiography focuses on the specific (idiographic)³⁶. Yet it is also the discipline of historiography that developed the general and widely applicable method of *source criticism*. This method is used not only in historical research but also in other disciplines for critically evaluating sources especially in forensic science, evidence-based medicine and jurisprudence³⁷. It is, for instance, used at the International Court of Justice and at the International Criminal Court to determine whether a source is authentic or whether it has been forged.

The notion of source criticism itself has a notable history. It can already be found in Herodotus who compared contradicting sources in terms of plausibility³⁸. It developed via Thucydides who only accepted sources based on eyewitness accounts³⁹, and Polybius who stressed personal experience as the most reliable source⁴⁰, into the more textual approach to historical source criticism that we find in the Roman republic and onwards, where written sources were regarded as the most reliable⁴¹. Unlike oral sources, written sources guaranteed some level of verifiability, but the problem of contradictory sources remained, and thus factors such as the authority of a written source played a fundamental role in determining whether to accept it as a reliable witness.

³⁵ Wilhelm Dilthey, *Einleitung in die Geisteswissenschaften: Versuch einer Grundlegung für das Studium der Gesellschaft und der Geschichte*, 1883, p. 29f. For an English translation, see Wilhelm Dilthey, *Selected Works*, Volume I, translated and edited by Rudolf Makkreel and Frithjof Rodi, Princeton University Press, 1991.

³⁶ Wilhelm Windelband, *Geschichte und Naturwissenschaft*, 3rd ed., Heitz, 1904. The discussions by Dilthey and Windelband are more subtle than summarized here. See Bouterse and Karstens, this Focus section, for more details.

³⁷ See Richard Riegelman, *Studying a study and testing a test: how to read the medical evidence*, Lippincott Williams and Wilkins, 2004. See also Charles Bazerman, *The Informed writer: using sources in the disciplines*, Houghton Mifflin, 1995; Lawrence McCrank, *Historical Information Science: an emerging undiscipline*, Medford, N.J., Information Today, 2002.

³⁸ Herodotus, *Histories*, 7, 139.

³⁹ Thucydides, *History of the Peloponnesian War*, 1, 22.

⁴⁰ Polybius, *Histories*, 1, 1-4.

⁴¹ See Bod, *A New History of the Humanities*, 24-26. See also G. E. R. Lloyd, *Disciplines in the Making* (Oxford: Oxford University Press, 2009), 67-70.

Usually, the nineteenth-century historian Leopold von Ranke (1795–1886) is credited with the invention of a systematic source criticism that aims to determine whether a document corresponds to historical reality⁴². Both the content of the source and its external facets, such as the form and the carrier, were subjected to a critical analysis. Yet, a very similar kind of source criticism had already been practiced several centuries before, first by early humanists, and later during the heyday of humanist historiography in the sixteenth and seventeenth century. One of the most illustrious examples of early source criticism is Lorenzo Valla's famous rebuttal of the document known as the *Donatio Constantini* in 1440⁴³. As is well known, the *Donatio* stated that the emperor Constantine had transferred authority over the Western Roman empire to Pope Sylvester I. It gave a justification for the church's worldly power. Although others had suggested earlier that the document was a forgery⁴⁴, it was Valla who convincingly showed that indeed the document could not have been written in the fourth century during the reign of Constantine. By combining the methods of historical, lexical and logical criticism, Valla showed that a number of events, words and phrases in the document were of medieval origin and that part of the discourse was in fact logically inconsistent. Valla's demonstration was so convincing that it was immediately accepted – even (initially) by the pope – until it was used by reformers like Martin Luther in their arguments against the church, and then placed on the Index⁴⁵.

While Valla's impact was impressive, source criticism probably had its greatest impact on early modern thought through the work of Joseph Scaliger (1540–1609) who was active at the University of Leiden in the late sixteenth and early seventeenth century⁴⁶. Scaliger aimed at unifying all ancient histories (Graeco-Roman, Babylonian, Egyptian, Persian and Jewish) so as to create the definitive historical chronology from the earliest era to his own time⁴⁷. In doing so, Scaliger not only had to compare many different calendar systems but a very large number of historical sources too. Scaliger therefore

⁴² See Kasper Eskildsen, 'Leopold Ranke's Archival Turn: Location and Evidence in Modern Historiography', *Modern Intellectual History* 5 (2008) 425–453. See also Lorraine Daston, 'Objectivity and Impartiality: Epistemic Virtues in the Humanities', in R. Bod, J. Maat and T. Weststeijn (ed.), *The Making of the Humanities, Vol. III: The Modern Humanities*, Amsterdam University Press, 2014, p. 27–42.

⁴³ Riccardo Fubini, 'Humanism and Truth: Valla Writes against the Donation of Constantine', *Journal of the History of Ideas* 57 (1996) 79–86.

⁴⁴ E.g. Nicholas of Cusa in his *De concordantia catholica*, 1433.

⁴⁵ For further background on Valla, see Lodi Nauta, 'Lorenzo Valla. Italian Humanist', in *The Classical tradition: a guide*, ed. Anthony Grafton, Glenn Most and Salvatore Settis (Cambridge, MA: Harvard University Press, 2010).

⁴⁶ For an in-depth biography of Joseph Scaliger and discussion of his works, see Anthony Grafton, *Joseph Scaliger: a study in the History of Classical Scholarship*, 2 vols. (Oxford: Oxford University Press, 1983–1993).

⁴⁷ Anthony Grafton, *Joseph Scaliger: A Study in the History of Classical Scholarship*, 2 volumes, Oxford University Press, 1983, 1993.

critically compared various historical texts, among them Manetho's list of Egyptian dynasties. Using the information from these sources, particularly about the duration of the different dynasties, Scaliger was able to date the beginning of the first Egyptian dynasty to 5285 BCE. To his dismay this date was nearly 1,300 years before the generally accepted day of Creation, which according to biblical chronology had to be around 4000 BCE. However, Scaliger did not draw the ultimate conclusion from his discovery, which would have meant that either the Bible or his own method was wrong. In order to 'save the phenomena', Scaliger introduced a new time pattern – the *tempus prolepticon* – a time before time⁴⁸. He placed every event that occurred before the Creation, such as the early Egyptian kings, in this proleptic time. Clearly, for a Protestant in around 1600 it was inconceivable to cast doubt on the Bible. Yet Scaliger was too consistent to give up on his critical method just like that.

But Scaliger's discovery appeared to be a time bomb. Only a couple of generations later, an increasing number of scholars – from I. Vossius to Spinoza – realized that the only possible interpretation of Scaliger's result was that the earliest Egyptian kings had actually lived before the Biblical date of the Creation. This meant that the Bible could not be taken seriously as a historical source. Scaliger's pattern of world history conflicted with biblical chronology, and this triggered a chain of biblical criticism that resulted in the early Enlightenment⁴⁹.

THE INFLUENCE AND IMPACT OF OTHER HUMANISTIC DISCOVERIES

The examples of the impact of the humanities on science and technology discussed so far are by no means exhaustive. A fuller account of the impact of the humanities should certainly also mention Leon Battista Alberti's work *De pictura* (1435), which provided the first theoretical description and analysis of linear perspective. Alberti developed a completely articulated method for the illusionistic reproduction of three-dimensional objects on a two-dimensional surface (the discovery of which he attributes to the sculptor and architect Filippo Brunelleschi). This method and its impact on painting literally changed our view of the world. It not only led to a revolution in European painting and art theory, but also to entirely new design techniques in architecture which were inconceivable without the use of linear perspective⁵⁰.

⁴⁸ Joseph Justus Scaliger, *Thesaurus temporum*, Joannem Janssonium, 1658 [1606], p. 278.

⁴⁹ At various places it has been shown that there is a direct line running from Scaliger via Saumaise and Isaac Vossius to Spinoza. See e. g. Jonathan Israel, *Radical Enlightenment*, Oxford University Press, 2002, and Eric Jorink, *Reading the Book of Nature in the Dutch Golden Age, 1575-1715*, Brill, 2010.

⁵⁰ See Bod, *A New History of the Humanities*, 211-216.

Neither should an overview of the impact of the humanities on the sciences overlook the exploration of musical dissonance and consonance by early humanists. The humanistic study of harmony revealed the synergetic interaction between theory and empiricism, which was passed on to the ‘new scientists’ of the seventeenth century, who elaborated it again in their own way⁵¹. This has in particular been studied in the relation between Vincenzo Galilei and his son Galileo Galilei. Vincenzo was a humanist, composer and music theoretician performing, among other things, experiments with the monochord. He experimented with strings of different lengths, materials and tensions, and aimed to refute some of the most influential musical theorists of his day (Giuseffo Zarlino) not just by theoretical considerations but by experiment. Galileo seems to have applied his father’s empirical methodology to his own experiments with balls rolled down an inclined plane. This intricate connection between music and nature was not new, as music theory had been treated as a matter of cosmological importance ever since Pythagoras⁵². What was new, though, was that the humanists employed a strongly empirical method for the study of their subject matter (music, but also texts), in which empiricism was to have the last word, no matter how fine the underlying theory was. And in doing so these early humanists created – or should we say, ‘discovered’ -- the synergy between theory and empiricism. They did so well before the ‘new scientists’ of the seventeenth century applied the empirical approach to the study of nature and brought it to great heights⁵³.

The examples given so far are the tip of the iceberg. We can remind ourselves how the nineteenth-century discovery of the Indo-European language family – which at the time was called ‘comparative philology’ – defined our view of the relationships between peoples, for better and worse. Among other things, this discovery gave a boost to scientific racism, in particular to the hypothesis of the existence of a ‘pure’ Aryan race, a theory which would be taken over much later by the National Socialists⁵⁴. This shows that the impact of the humanities is not necessarily positive. The claim that the humanities are essential to a critical mentality and democracy (as

⁵¹ Penelope Gouk, ‘The Role of Harmonics in the Scientific Revolution’, in *The Cambridge History of Western Music Theory*, ed. Thomas Christensen (Cambridge: Cambridge University Press, 2002), 223-245.

⁵² H. Floris Cohen, ‘Music as Science and as Art: The 16th/17th-Century Destruction of Cosmic Harmony’, in R. Bod, J. Maat and T. Weststeijn (ed.), *The Making of the Humanities, Vol.1: Early Modern Europe*, Amsterdam University Press, 2010, p. 59-71.

⁵³ See Rens Bod, *Een Wereld Vol Patronen: De Geschiedenis van Kennis*, (“A World of Patterns: The History of Knowledge”), Prometheus, 2019, chapter 6. See also Stillman Drake, ‘Renaissance Music and Experimental Science’, *Journal of the History of Ideas* 31 (1970) 483-500.

⁵⁴ Stefan Arvidsson, *Aryan Idols: Indo-European Mythology as Ideology and Science* (Chicago: University of Chicago Press, 2006), 241 f.

Martha Nussbaum contends⁵⁵) may deserve a more nuanced discussion⁵⁶. For nineteenth-century scholars like Friedrich Max Müller and Christian Lassen it was straightforward that the linguistic evidence for an ur-language meant that there was a pure Aryan race and that some other races were endlessly mixed and impure⁵⁷. Some of the most critical linguists and philosophers of the time accepted this view. If we want to describe the history of scientific racism, we cannot leave out the history of comparative philology.

We should also add some examples from the more recent humanities disciplines such as film studies and television studies. In film studies, for example, scholars have developed methods of analyzing film by integrating insights from semiology, literary studies and linguistics. We see this most clearly in the work of Christian Metz (1931-1993) who developed his “Grande Syntagmatique” in which he called the building blocks of film *syntagmas*. In the spirit of Noam Chomsky’s generative syntax⁵⁸, Metz designed a number of theoretical principles to create a hierarchical organization for these syntagmas so that the cinematic structure of the film as a whole could be visualized and interpreted. Such a cinematic narrative structure is represented by a tree diagram where the leaves of the tree represent film scenes and the branched structure reflects the relationships between the scenes – see Fig. 1.

⁵⁵ Martha Nussbaum, *Not for Profit: Why Democracy Needs the Humanities*, Princeton University Press, 2010.

⁵⁶ See in particular William Bridges, “A Short History of the Inhumanities”, *History of Humanities*, 4:1 (2019) - in press.

⁵⁷ See Georges Vacher de Lapouge, ‘Old and New Aspects of the Aryan Question’, *The American Journal of Sociology*, 5:3 (1899) 329-346.

⁵⁸ Noam Chomsky, *Syntactic Structures*. The Hague: Mouton, 1957.

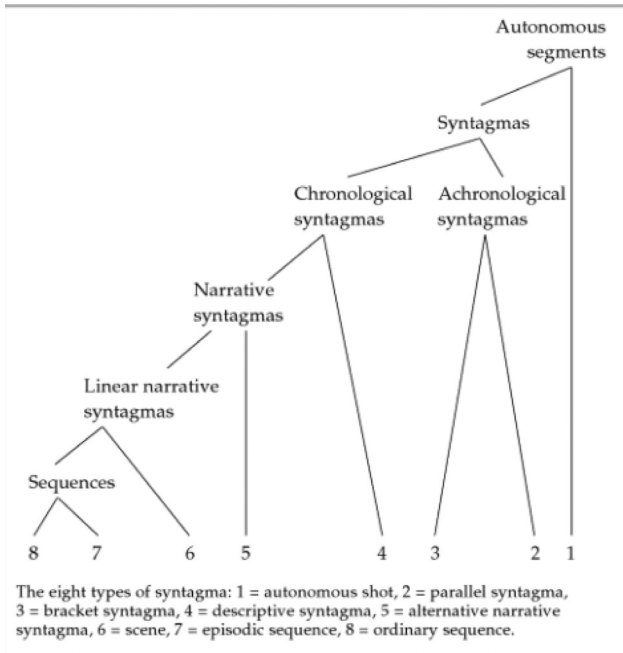


Fig. 1 - Christian Metz's "Grande Syntagmatique".

Warren Buckland, *The Cognitive Semiotics of Film*, Cambridge University Press, 2000, p. 115

This formal analysis into building blocks has led to some surprising results. For example, the narrative structure of the popular television series *CSI: Crime Scene Investigation*, which has dragged on for years, has been found to consist of only eight narrative building blocks that are endlessly reshuffled⁵⁹.

Another important insight from the analysis of the medium of television indicates that viewers are captured through 'flows' – *i. e.* non-stop streams of information, advertising, entertainment and trailers – whose purpose is to keep the viewer tuned to a particular channel⁶⁰. Time will tell whether these insights and discoveries will have applications in science or technology, but they are in any event sensational.

⁵⁹ Benedikt Löwe, Eric Pacuit and Sanchit Saraf, "Identifying the Structure of a Narrative via an Agent-based Logic of Preferences and Beliefs: Formalizations of Episodes from *CSI: Crime Scene Investigation*TM", *Proceedings of the Fifth International Workshop on Modelling of Objects, Components and Agents, MOCA'09* (2009), p. 45-63.

⁶⁰ Raymond Williams, *Television: technology and cultural form* (London: Collins, 1974).

CONCLUSION

My review of the impact of the humanities has only scratched the surface, but it has made clear that insights from the humanities have had a profound influence on science, technology and society. The humanities gave us grammar formalisms (linguistics) that were used in the development of high-level programming languages. The humanities provided tools for text reconstruction (stemmatic philology) that could be applied to DNA analysis. They also developed widely applicable source-critical methods (historiography) which are used in variety of fields, from forensics to medicine. And the humanities most probably invented the empirical cycle of research, where empiricism gets the last word no matter how beautiful the theory may be (early humanism). A thorough understanding of the development of systematic knowledge must therefore include both (the histories of) the humanities and the sciences. To do so, we must put aside our preconceptions, and study the scholarly texts, practices and methods from the past anew⁶¹.

⁶¹ For such an attempt, see *e. g.* Rens Bod, *Een Wereld Vol Patronen: De Geschiedenis van Kennis*, (“A World of Patterns: The History of Knowledge”), Prometheus, 2019, to appear in English in 2021.