

Language as Scientific Instrument: a Preliminary Digital Analysis of Christiaan Huygens' Last Writings and Correspondence

Ludovica Marinucci^(a)

a) University of Cagliari, Italy

Contact: Ludovica Marinucci, lud.marinucci@gmail.com

Received: 29 October 2017; Accepted: 12 February 2018; First Published: 15 May 2018

ABSTRACT

This essay focuses on a digital text analysis with *AntConc* computational linguistics tool in order to find, list and compare the most important key word occurrences and their collocations in some of Christiaan Huygens last writings, from 1686 to 1695 and posthumous. The greatest attention is paid to three key words – *Animus*, *Potentia* and *Lex* – related to the themes of God's power, divine and human intelligence, probabilistic epistemology, natural theology and plurality of worlds. In addition, these key words are used to select the letters written by Huygens to the most important of his contemporaries on the same topics. This challenge firstly involves demonstrating that his last writings on philosophical and theological reflections on mechanistic philosophy are not an anomaly within Huygens' wider work, and secondly showing that these are indications of Huygens' involvement in a number of theoretical debates in the second half of the seventeenth century.

ACKNOWLEDGMENTS

I would like to express my very great appreciation to Dr Charles van den Heuvel, Eric Jorink and Peter Boot (Huygens ING) for including me in their research activities. In addition, Dr Walter Ravenek, developer of the ePistolarium tool, provided me with very valuable assistance in the database's collection of Huygens' correspondence. Advice given by Dr Isabella Chiari (Sapienza University of Rome) has been a great help for computational lexicography techniques. Finally, I wish to thank Dr Nicola Barbuti (University of Bari) for his useful critiques on this paper and Jacopo Condò (PhD Candidate at University of Brighton) for advice and revisions of the English version.

KEYWORDS

History of Science; Christiaan Huygens; Digital Text Analysis; Lexicon; AntConc corpus analysis tool.

CITATION

Marinucci, L. "Language as Scientific Instrument: a Preliminary Digital Analysis of Christiaan Huygens' Last Writings and Correspondence". *JLIS.it* 9, 2 (May 2018): 1-17. DOI: [10.4403/jlis.it-12449](https://doi.org/10.4403/jlis.it-12449)

Introduction. Underlying Problems in the History of Ideas

Christiaan Huygens: a Thinker Hard to Place?

Compared to the impressive 22 volumes of the *Œuvres Complètes* (Huygens 1888-1950),¹ which makes available most of the correspondence and writings of the Dutch scientist Christiaan Huygens, few studies are devoted to his work (Mormino 1993). During the two conferences² for the 350th anniversary of Huygens' birth, many historians of science questioned this odd gap in critical literature in view of the common critical judgment that Huygens' works are among the most relevant of his time. The reasons might be that the exegesis produced by the editors of the *Œuvres Complètes* apparently explored the main research issues (Gabbey 1980) and that their rich commentary had a paralyzing effect on historians of science (Hall 1980). However, most significant studies over the last twenty years have highlighted Huygens manuscripts kept in Leiden, showing how the national edition is not unquestionable and, on the contrary, how the formation of dogmatic interpretations of the Dutch scientist's activity is the consequence of the adoption of "non-neutral" editorial criteria (Mormino 2003). In fact, the reconstruction performed by the editors has often hidden the context and process of his discoveries, outlining the image of a scientist who can easily solve a problem that seems to be clear from the beginning and, consequently, ignoring the fundamental features of his research. Emphasis on the published works at the expense of the ongoing drafts might be one of the main reasons why most of the critical studies have focused on aspects, as various as they are specialized, of Huygens' scientific activity (Yoder 1998). Therefore, only two studies reconstruct the epistemology underlying his speculation as predetermined by a supposed "Cartesianism" (Elzinga 1972) or by a lack of systematic thought (Burch 1981).

The problem related to the philosophical structures that support his scientific investigations remains unsolved and it is still difficult to articulate Huygens' conceptually autonomous and coherent vision, denied by various historians of science. On the one hand, the image of a scientist engaged only in the collection and analysis of facts and far from metaphysical concerns contributed to devaluing its importance by promoting only the appreciation of his still valid scientific results and his commitment to a "modern" mathematical analysis of the physical world (Mach 1883, Cassirer 1907). On the other hand, the unresolved issue of his belonging to scientific Cartesianism, even if "heterodox" (Koyré 1965), led to the conclusion that Huygens' thought lacked a philosophical foundation. According to these scholars, Huygens was an exception in his time: a problem-solver detached from the methodological, philosophical and theological debate that took place around him. However, some more recent studies have argued that Huygens was a thinker who did not easily fit the predetermined and opposed categories, such as Cartesianism and English Empiricism, which historiography would

¹ From now on, this editorial edition is shortened to OC followed by the volume number in Arabic numerals.

² "Huygens et la France, table ronde du CNRS", Paris 27-29 March 1979; "Studies on Christiaan Huygens, invited papers from symposium on the life and work of Christiaan Huygens", Amsterdam 22-25 August 1979.

employ. This attitude might be one of the main causes of the silence surrounding these last writings inspired by a greater reflective vocation (Bos 1982, Chareix 2003).

Therefore, from an historical point of view, we can remark that Huygens' philosophical role has not yet been satisfactorily defined. The same understanding of his major work of this period, namely the *Cosmotheoros* (1698),³ and in particular the most speculative Book I, was widely discussed by critical literature between the 1970s and 1990s. It was either regarded as the product of a mature wisdom (Hooykaas 1979, Andriessse 1993) or of a natural weakening (Romein 1977, Hall 1980) of the Dutch scientist's intellectual capacity.

My research follows and supports the thesis, consolidated by the most recent critical studies,⁴ of the reevaluation of the philosophical purpose in Huygens' last writings, which was also in continuity with the scientific method of his previous works.

Why the Very Last Writings?

Having considered the different positions of these scholars, I selected those of Huygens' last writings that seem characterised by a relevant presence of speculative reflections showing both his rationality model and his attitude towards religion. In this way, they are able to undermine the commonplace view of a scientist detached from genuine philosophical concerns. These texts are both published works and unpublished materials, such as handwritten and undated *folia*, notes, preparatory studies and appendices, dating to a period between 1686 and 1695. This period is particularly relevant in the evolution of Huygens' thought because of two notorious historical events: the Revocation of the Edict of Nantes and the publication of Newton's *Principia mathematica*.

The greatest attention is paid to the main work of this period, namely the *Cosmotheoros* – edited posthumously in 1698 by his brother Constantijn – which I compared to some unpublished writings that, in a different way, may be considered as its preparatory drafts. Most of them were collected by the *Œuvres Complètes* editors in the XXI volume, with the thematic title of *Cosmologie*. Several of them have astronomical themes and issues related to the plurality of worlds and their inhabitants;⁵ some add considerations about natural theology and divine and human intelligence;⁶ and others focus on reflections related to humankind as microcosm, to society, life and death, and desire of glory.⁷ In addition, I selected some other unpublished works, which were collected in other volumes, regarding Huygens' thoughts on perception, in particular related to the functioning of the eye, the sense of sight⁸ and of hearing, associated with his theory of musical consonants.⁹

³ OC 21, *Cosmotheoros*.

⁴ See in particular: Vermij 2002, Mormino 2000 and 2003, Chareix 2003 and 2003a, Radelet de Grave 2003.

⁵ OC 21, *Astronomica Varia 1690-1691*, De probatione ex verisimili, Verisimilia de planetis, Insolitum spectaculum.

⁶ OC 21, *Pensees Meslees*, Que penser de Dieu, De rationi imperviis, Quod animalium productio.

⁷ OC 21, Appendice aux pièces 'De rationi imperviis, De gloria, De morte.

⁸ OC 13, De l'œil et de la vision.

⁹ OC 19, *Rapports des longueurs des cordes consonnantes*; OC 20, *Pièces sur le chant antique et moderne, Théorie de la consonance*.

During the analysis of these writings on cosmological, theological and epistemological themes, I also took into account his works related to physical experiments both preceding¹⁰ and contemporaneous¹¹ to the considered period with special regard to those parts in which Huygens remarks upon methodological issues and criticises some ancient and modern philosophical approaches. In these writings on physics, emerges a theory of mechanistic motion, which in Huygens' mature thought can be defined as "atomistic" (Mormino 2012, 63–109). This poses an interpreting problem in his conception of the teleology of Nature discussed in the *Cosmotheoros* and its preparatory writings. Fabien Chareix described Huygens' last years of work as "la période critique" (Chareix 2003, 10) because Huygens failed to complete his draft of a unified theory on movement. However, Gianfranco Mormino's analysis of the *Codex Hugeniorum 7A* showed how the Dutch scientist comes to an integration of the circular motion within the class of relative movements, founding the laws of mechanics in a unique relative movement. Moreover, from the correspondence with Leibniz has come to light not only Huygens' conception of matter but also, thanks to the stimulus of Newton's work, his attempt to convert scattered ideas about movement, strength, distance or cosmic system into a consistent and "hyperphysical" way of thinking (Mormino 1998). This attempt led the Dutch scientist to write: "Non est mathematice difficilis materia, sed physice aut hyperphysice".¹² This expression, dating back to about 1688, bears witness to a Huygens' coherent attitude in being able to connect his physical-theological rhetoric with the evaluation of his mechanistic philosophy.

Therefore, having considered that Huygens' epistemology makes use of the divine design argument, I tried to highlight his theological understanding of natural order as well as the consequent relationship between God and Nature, terms that are often synonymous in his works. My attempt follows the thesis of those scholars claiming that, in the course of the seventeenth century, the collapse of the medieval symbolic interpretations of nature would raise fundamental questions about the meaning of nature itself: divine design, providence and teleology would be elements of a wider metaphysical debate on the new mechanical conceptions of nature (Harrison 1998, Funkenstein 1986). In this respect, I chose also to analyse Huygens' correspondence with prominent thinkers involved in this debate. Hence emerges not only his interest in the main post-Cartesian philosophical-scientific controversies but, above all, his consideration of his *Cosmotheoros* as in no way disconnected from his previous scientific work: even though he recognises its particular form and content, he refers to it in several letters as "un petit traité en matière philosophique".¹³ As well, Mormino pointed out the importance of the last correspondence that would reveal Huygens' attention to epistemological issues. According to the Dutch thinker, science does not concern the possible but only the existing;

¹⁰ OC 16, De motu corporum ex percussione, Pièces et fragments concernant la question de l'existence et de la perceptibilité du 'mouvement absolu', Extrait d'une Lettre de M. Hugen à l'Auteur du Journal.

¹¹ OC 19, Traité de la Lumière; OC 21, Discours de la cause de la pesanteur.

¹² OC 16, Pièces et fragments concernant la question de l'existence et de la perceptibilité du 'mouvement absolu', 213. See also: Portfolio L, 5 in which Huygens firstly wrote "metaphysice" and then corrected it with "hyperphysice".

¹³ Letter to Leibniz, OC 10, n. 2854, 29th May 1694, 609 (my emphasis): "Cette attente m'a donc fait differer longtemps de vous escrire. Apres cela sont venu des etudes nouvelles un petit traité en matiere Philosophique". See also the letter to Marquis de l'Hôpital: OC 10, n. 2842, 24th December 1693, 577.

thus, an endless variety of Creation must not be assumed *a priori* but it is necessary to rely on experience and, in its absence, on a probabilistic evaluation (Mormino 2012).

Comparing Corpora and Archives: the Challenge of Interpreting an Author through his Lexicon

The Huygens Database and the AntConc Tool for Concordancing and Text Analysis

My main aim was to find a lexicon able to reconnect the conceptual apparatus underlying the Huygens' speculative reflections, whose constitutive elements, although not expressed in the canonical forms of philosophy, weave the same theoretical narrative as the greatest philosopher-scientists of his time. I intended to carry out a linguistic analysis finalized not to display the author's thought based on a preconceived interpretation, but to evaluate Huygens' conceptual system by providing a linguistic data processing and as objective a description of it as possible. Following the method, as valid in philology as in computer science, based on the assumption of an ideal unity of meaning without internal contradictions in a text, I could evaluate – for the first time in Huygens' work – whether this consistency of meaning exists and eventually can be understood or not, in order to highlight any contradictions in the system.¹⁴ At the same time, I tested the working process of the computer tool, as it adapted to reach the objectives and create new paths to investigate, in a similar way to the scientific experimentations carried out by Huygens, who built his own “philosophical instruments” (Bertoloni Meli 2006, 5) or “embodied theories” (Koyré 1968, 113).

My text analysis has followed the linguistic “corpus-based” approach (Tognini Bonelli 2001, 65–83) that I adapted to my philosophical problem outlined above. Therefore, since my questions were not, strictly speaking, linguistic, I decided to choose not a generic and enormous “reference corpus” (Chiari 2007, 51) but the specific one of the letters of Huygens and his correspondents.

My database, composed of very heterogeneous texts, is structured in two parts:

1. A primary collection of Huygens' last writings, which are different in both size and subject. Selected according to the criteria outlined above, I mainly focused on this *corpus* in comparing between some chosen terms and their contexts in order to examine any variations of meaning so that we can term them as “concept-lemma”.
2. A secondary collection consisting of the Huygens' complete correspondence (3090 letters). I pulled out the same *concept-lemmas* of the primary corpus in order to analyse them from a historical point of view.

These key words are significant thematic nuclei around which Huygens gets to the heart of a number of well-known philosophical debates in the second half of seventeenth century.

¹⁴ I followed the methodological approach of philology and translation outlined in Hohenegger 2011, 65–66.

In order to create my database, I took advantage of the material published on the *Digitale Bibliotheek voor de Nederlandse Letteren* (dbnl)'s website, which makes freely available the Huygens' complete work edited by the *Société Hollandaise des Sciences*. After I had collected the texts in digital format, I had to delete prefaces, comments, quotes, footnotes, and all editorial criteria performed by the *Œuvres Complètes*' editors with a view to being able to process and interpret preliminary quantitative data relating to the author's language only. This kind of preparatory work was less demanding for the correspondence's corpus, directly processed without the critical apparatus thanks to the helpfulness of the Huygens ING researchers, who set it up in light of the *ePistolarium* tool's development. In addition, I made a comparison of both corpora with the *Codices Hugeniorum* manuscripts consisting of a uniformity check and correction of the inevitable errors due to the large amount of data processed during the conversion in OCR character recognition. For this comparison I followed the indications provided by Joella Yoder's *Catalogue* (Yoder 2013), in which she describes and orders each manuscript *folio* by marking it as unpublished or reporting the correspondent pages in the *Œuvres Complètes*.

Subsequently, I carried out a classical automatic text analysis (e.g. Sinclair 1991) by means of the *AntCont* tool (Anthony 2014, Version 3.4.3)¹⁵ following a methodological indication by Huygens himself. Having compared physical investigation to the decryption of a letter written in code, he stated that, during the elaboration of an interpretative hypothesis, the existence of a meaning to be discovered must be a given: that is, it must be assumed as an internal rationality in the object being investigated (OC 7, Letter n. 1944, 298–301).

I firstly used the *Word Lists* search option that allows the extraction of word frequency lists. Having considered the corpus' multilingualism (Neo-Latin, French, Dutch, English, Italian), I decided to obtain a frequency list for each language in order to have the chance to compare more accurately both the semantic variation of *lemmas* and the quantitative prevalence of one language over another. Reading these first outputs, there emerged a set of linguistic data previously unknown: that is, the presence of Greek terminology, with scientific and non-scientific meaning, especially in Latin contexts. Therefore, starting from these frequency lists, I chose several of the most significant terms both in Huygens' last writings and in the history of ideas in the second half of the seventeenth century. I paid special attention to Latin as a substratum of the national European languages' terminology in scientific and humanistic culture, which has conditioned the elaboration of modern philosophical and scientific thinking (Gregory 2006, 82–83).

Secondly, I conducted a series of preliminary tests and comparison of many terms, such as *Deus*, *ratio / ratiocinium*, *experientia / experimentum*, *potentia / potens*, *intellectus / intellegibilis*, *sensus / sensibile*, *gravitas*, *vortex*, *atomus*, *vacuum*, *infinitum / infinitas*, *continuum* etc. I was looking to verify for each of them not only the number of occurrences but also their co-occurrences by means of three software tools. The *Cluster* search option shows word groups based on the search term, which are

¹⁵ The developer proposes a model for this corpus tool design and development as his answer to the long running debate in the field of corpus linguistics research “concerning the size and annotation of corpora” and the “differences in the outputs of corpus linguistics tools” (Anthony 2013, 144–45). For a features description of this standalone software package for linguistic analysis of texts see: Froehlich 2015.

displayed together with the words immediately on the right and left; the *N-Grams* search option, by analysing the whole corpus for ‘n’ length clusters, allows you to find common expressions; and the *Collocates* search option makes it possible to investigate non-sequential patterns in a language.

Eventually, my latter choice of *concept-lemmas*, on which I mainly focused my interpretative analysis, was based on the *Concordance* search option, which shows the list of phrases commonly used for each searched term, namely KWIC – *Key Word In Context* (Fig. 1).

The purpose of this long preliminary analysis was to find, list and compare the most important key word occurrences and their collocations that the research progress has suggested as more significant for a first but consistent study of Huygens’ thought through his own language. In accordance with the well-established recognition of the necessity of both a quantitative and qualitative approach to understand the “system” and the “use” of a language (De Mauro 1995), I especially took into account those computational studies that support an epistemological point of view. A useful guideline was Richard Watson Todd’s attempt, based on the lexical priming theory (Hoey 2005), to distinguish between existing and new knowledge by comparing the relationships between what he defines as “concepts” – namely the key words – and their “associations” (close-span key word linkages) – namely the collocations – and “conceptual associations” (wide-span) – namely the co-occurrences (Watson Todd 2013). Therefore, in an actual comparison of the author with his terminology and that of his different contemporaries, I tried to highlight and to analyse the “intellectual vocabulary” (Russo 2012, 171) of the Dutch scientist as a vehicle of representations and relevant concepts in his intellectual history.

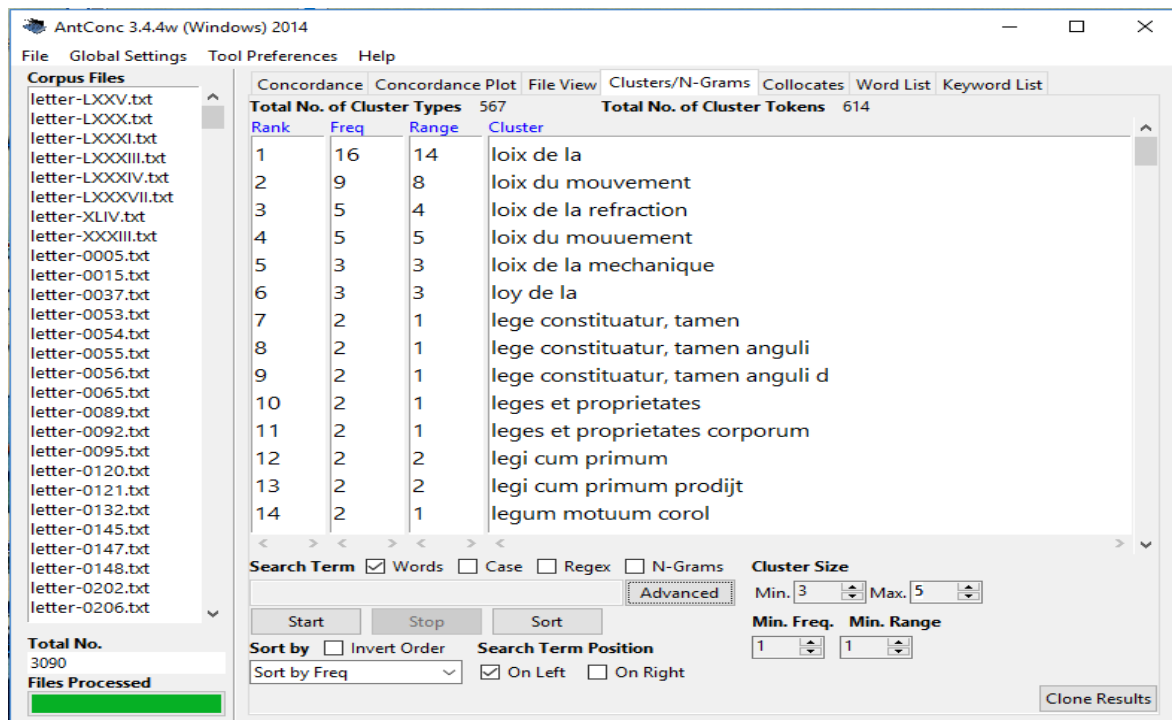


Figure 1: AntConc Cluster Tool.

Three *Concept-Lemmas* Case Studies: “Soul”, “Power” and “Law”

As a result of the preliminary digital texts analysis, I chose three *concept-lemmas* as case studies, namely “soul”, “power” and “law”. They represent the common thread of my interpretative analysis in which I tried to link, from a strictly theoretical point of view, Huygens’ last and philosophical writings with a historical perspective of the correspondence’s reading. My final decision about these three *concept-lemmas* was based on their peculiar semantic variation in his last writings’ contexts as well as on the recognition of their relevance in the modern philosophical tradition.

In the course of this analysis, I compared the *lemmas* with others consisting of their synonyms and collocations, such as *regula, usus rationis, finis, miracula*, etc. They can be defined as secondary, even if they are often decisive elements of support to interpret Huygens’ speculations. I examined this lexicon through the juxtaposition and concatenation of its contexts related to very different themes. In this way, I tried to retrace Huygens’ continuity of thought, even in its evolution and maturation, and to describe it through a system of internal referrals to his own texts that makes conceptually readable every juxtaposition of each *KWIC* as a whole to be recreated.

By way of the *AntConc* ‘advanced search’, I was able to trace the variations of search terms through regular expressions, which are able to take into account the variations of each lemma (singular, plural, and Latin declinations) in the five languages within the corpus.

In the case study of “soul”, I mined the lemmas *animus / anima* and *âme* for Latin and French writings and correspondence as well as *mind / soul, ziel / geest* and *animo* for English, Dutch and Italian letters. During their occurrences analysis, I was able to trace relevant collocations, such as *voluptas animi, immortalitas animi, usus rationis* etc., and further co-occurrences from the search term, such as *mens / esprit, ratio / raison, sensus / sens*, which as synonyms or related and comparative words suggest additional semantic nuances of “soul”.

In the case study of “power”, I looked for *potentia / potestas, puissance / pouvoir* in Latin and French last writings and correspondence and for *power, macht / vermogen* and *potenza* in English, Dutch and Italian letters. In French writings, given the great amount of occurrences of the term *pouvoir*, I selected only its substantivized forms that refer to a theological and epistemological shade of meaning. This *KWIC* analysis allowed me to trace very tied collocations, such as *potentia dei* (or its synonymous *conditor* and *auctor*), *infinita / immensa potentia*, and other co-occurrences more distant from the search term, such as *providentia / providence, voluntas / volonté, probabilis / probable, mens / esprit* and *intellectus, fides / foy* and *ratio / raison* etc.

In the case study of “law”, I searched for the lemmas *lex,-gis / ley, loix* in Latin and French last writings and correspondence, whereas in English, Dutch and Italian letters I tried with the lemmas *law(s), wet / recht* and *law*. During this automatic textual analysis, two main collocations emerged, namely *lex motus / ley du mouvement* and *lex naturae / ley de la nature* as well as a number of very significant Latin synonyms, such as *praescriptum, jussu* and *regula*, and co-occurrences, such as *providentia / providence, finis / fins, miraculum / mirabilia / miracle*.

In all these three case studies, the co-occurrences repeated significantly in their respective word clusters turned out to be an essential way to connect the three major key words to each other. Then,

I ordered the “soul”, “power” and “law” concordances into lists dividing those in the writings from those in correspondence. This second list is further divided into sub-lists according to both the language of the *Key Word In Context* (KWIC) and of its co-text (Context). Moreover, in addition to their frequency (F), the letters – sorted chronologically – are provided by the sender and recipient names in the “Metadata” (Fig. 2).

For each case study, I searched for the three key words, their synonyms and collocations in a number of databases, archives and thesauri referring to the same or previous period being considered.¹⁶ This further research was based on both random hypothesis and previous knowledge of most of the main thinkers in the history of ideas.

	B	C	D	E	F
1	. Et il nest pas besoin d'une moindre	puissance	pour conseruer, ou reproduire a chaque i	letter-LI.txt	1
2	lieu de x et de y, et les	puissances	de ces premieres quantitez au lieu des	letter-LXXIV.txt	1
3	puissances de ces premieres quantitez au lieu des	puissances	des dernieres, la nouvelle equation ren	letter-LXXIV.txt	2
4	contiennent les lettres x ou y, ou quelques	puissances	de ces lettres, on substitue les quanti	letter-LXXIV.txt	3
5	quantitez x + z, ou y + u, ou les	puissances	correspondantes de ces quantitez, desqu	letter-LXXIV.txt	4
6	nces correspondantes de ces quantitez, desquelles	puissances	correspondantes le premier terme est to	letter-LXXIV.txt	5
7	correspondantes le premier terme est toujours la	puissance	même de x ou de y qui est	letter-LXXIV.txt	6
8	sont toujours les seconds termes des differentes	puissances	de x + z et de y + u qu'	letter-LXXIV.txt	7
9	+ u qu'il faut écrire, au lieu des	puissances	correspondantes de x et de y que l'	letter-LXXIV.txt	8
10	termes se trouvent aisement par le moien des	puissances	données de x et de y, comme il	letter-LXXIV.txt	9
11	aroit par les tables suivantes, en multipliant la	puissance	de x ou de y par le nombre	letter-LXXIV.txt	10
12	ce que l'on a trouvé par les	puissances	de x et de y qui le multiplient,	letter-LXXIV.txt	11
13	changé en z, c'est à dire une	puissance	lineaire de x qu'il faut faire paroître	letter-LXXIV.txt	12
14	, où je regarde la quantité z comme une	puissance	lineaire de x, et la quantité u, comme	letter-LXXIV.txt	13
15	de x, et la quantité u, comme une	puissance	lineaire de y. C'est pourquoi si on	letter-LXXIV.txt	14
16	'equation de la courbe; où xm marque la	puissance	de x, dont m est l'indice; et	letter-LXXIV.txt	15
17	de même yn, et gm-n-1 marquent les	puissances	de y, et de g, dont n, et	letter-LXXIV.txt	16
18	au Sieur Gobert: car il a plus de	puissance	sur la paresse du Sr. Ballard que moy:	letter-0024.txt	1
19	au cube de FC, ou bien de telle	puissance	d'AB que l'on voudra à la	letter-0051.txt	1
20	d'AB que l'on voudra à la	puissance	de du mesme degré de FC, donner la	letter-0051.txt	2
21	exiger. Vous scavez trop bien quelle est mon	impuissance	en pareille matiere et que je ne scaur	letter-0237.txt	1
22	donne ce Theoreme. Il n'y a aucune	puissance	dont la racine soit vn nombre premier, e	letter-0383.txt	1
23	au Cube et l'autre a la 9eme	puissance	, et les reduit aprez a vne seule Equatio	letter-0599.txt	1

Figure 2: file sheet of the KWIC “power”.

¹⁶ Among others, I especially refer to: *The Works of John Locke in Nine Volumes* (Online Library of Liberty), Early Modern Letter Online (EMLO), *Banca dati di testi filosofici dell'età moderna* – Lessico Intellettuale Europeo e Storia delle Idee (ILIESI-CNR), *Daphnet Modern Philosophy* (ILIESI-CNR), *Lessici filosofici di età moderna* (ILIESI-CNR), *Centre National de Ressources Textuelles et Lexicales*, *Trésor de la Langue Française informatisé*, *Analyse et Traitement Informatique de la Langue Française*.

Results Obtained with Two Complementary Approaches of Computational Lexicography

A Quantitative Analysis

The first step was to analyse the quantitative outputs, namely each *concept-lemma*. Below I try to summarize for each case study the most relevant ones in their lists of word frequency and collocations.

In the case study of “soul”, firstly it is remarkable the prevalence of Latin occurrences in both Huygens’ writings and correspondence is remarkable: data of further importance because of the great diversity – for size and style – of the two corpora. In French writings, there are only 13 occurrences within three writings out of 15 processed by the *AntConc* tool; instead, in Latin, *animus,-i* and *anima,-ae* number 41 items in seven writings out of 15. Moreover, in the correspondence the trend seems to be the same. Only in 29 of 1947 French letters, we count 32 occurrences of *âme(s)*. On the contrary, in the 787 Latin letters there are 126 occurrences of *anima* and *animus*, to which we have to add the other 10 Latin occurrences within the 25 mixed Latin-French letters, consisting of mostly French text with a significant presence of Latin sentences or entire paragraphs.

Secondly, another relevant result is the predominance of Latin occurrences in their declension of the male lemma *animus,-i*, which seems often to have the same meaning as *mens,-tis*, a term rather less frequent also in philosophical contexts, in which Huygens seems to prefer *ratio,-nis*.

Thirdly, it is interesting to note the use of this lemma in sentences consisting of figures of speech or letter endings. These kinds of occurrences are the prevalent ones in Dutch, English and Italian letters. In the 215 Dutch letters, there occurs only once the lemma *ziel*, literally *soul*, and six times *geest*, translatable as both *mind* and *spirit*. In the 52 English letters, *soul* never appears in favor of seven occurrences of *mind*, with a similar meaning to the 13 items of *animo* in the 42 Italian ones.

From a chronological point of view, this *concept-lemma* in the correspondence reveals the evolution of Huygens’ attitude relating to the post-Cartesian issue on the immortality of soul and on whether or not animals possess it. It seems that from the 1770s, his interest began to emerge as a careful exchange with his inner circle until it became a clear stance in the early 1790s, argued openly in the last philosophical writings.

In the case study of “power”, the most significant outcome is the very different meaning of the term as ‘divine power’ in the last writings and as ‘arithmetic power’ in all the correspondence. From a semantic point of view, the two corpora are opposed to each other.

In addition, if in the writings primacy is assigned to theological meaning with the clear collocation of *potentia Dei / puissance de Dieu*, another contrast emerges systematically: the lemma *potentia / puissance* is always opposed to the human *potestas / pouvoir*, which can be transposed as men’s intellectual ability and, at the same time, as their right to do something.

On the other hand, in his correspondence Huygens has never used the collocation “power of God” in any languages of this corpus, nor even in those letters dating from the same period as the last writings here considered. This lack seems to be a strong position by Huygens in face of its use by

some of his contemporaries in theological and epistemological debates in which they sought unsuccessfully to engage him. In the other languages, especially in English and Dutch, only “Almighty God” is used in figures of speech or letter endings. Conversely, the massive presence of arithmetical *power* in the correspondence testifies that Huygens was one of the most important points of reference in the major scientific debates of the second half of the seventeenth century, especially in solving mathematical problems. In fact, according to the Dutch scientist, the only truly reliable thing was reasoning, unlike the weak arguments in theological controversies.

In the case study of “law”, unlike in the previous one, the most remarkable result is the recognition of a quantitative and semantic equivalence (both in singular and plural forms) of French and Latin occurrences in the last writings. The same trend can be found in these two languages even throughout the correspondence.

Moreover, there is another similarity in the two corpora consisting of the presence of three main collocations as synonyms in both French and Latin, namely “law of motion”, “law of mechanics” and “law of nature”. However, in the writings this last collocation plays the role of implicit reference to law as a part of divine design: it is confirmed by the use of its synonym collocation *praescriptum naturae*. In this case, the identification of relevant synonyms and collocations was crucial to highlight some underlying argumentations in the last writings, such as the interchangeability of the terms “Nature” and “God”.

From this terminological consistency, it is possible to infer Huygens’ strong continuity of interest in the issues addressed in both the correspondence and last writings. The latter do not abandon research in the fields of physics and astronomy, which actually are the foundations of Huygens’ cosmogonic and anthropological speculations.

A Qualitative Analysis

After the quantitative analysis as presented above, the second step was to interpret the concordances of the three *concept-lemmas* in their different contexts. This type of approach, which allowed me to establish which of Huygens’ works contain the most interesting meanings of the chosen key words, also enabled the detection of the theoretical elements of continuity between the correspondence – mainly bound to scientific themes – and the philosophical sources re-elaborated by Huygens in his last writings. The elements of continuity can be summed up in three main themes.

The first consists of Huygens’ probabilistic epistemology. He adapted his early mathematical studies on random probability to his methodological concern to accept a “degré de vraisemblance”¹⁷ during his physical investigations in absence of mathematical certainty. In his last writings, this research methodology appears also in his epistemological considerations on natural philosophy. By means of the analytical interpretation, possible only thanks to the computer tool, I have been able to recognize an interesting similarity to the ideas expressed by Locke in *An Essay Concerning Human*

¹⁷ OC 19, *Traité de la lumière*, 454; see also OC 21, *De probatione ex verisimili*, 541.

Understanding, which may add philosophical value to the probabilistic arguments on the nature of other planets and of their inhabitants in the *Cosmotheoros*.

The second is related to his thinking on animals. They are machines with a soul that differs from ours only on the rational side. These reflections are able to open a window on Huygens' religiousness and show his interest in and standpoint on a still open post-Cartesian debate. The "miracle"¹⁸ of the animals' generation would fit in the mechanical laws of nature, since there was not a unique creation, but many of them.¹⁹ Therefore, I may include Huygens in the circle of "English empiricists", following the distinction made by Robert M. Burns. In fact, in seeking an explanation of miracles in the context of mechanical philosophy, the empiricists do not try, as the "continental rationalists" Descartes, Spinoza, Malebranche and Leibniz, to fill a gap in the scientific explanation but to use them as practical evidence of the Christian truth and as *a posteriori* proof of God's existence (Burns 1981).

The third is present in Huygens' conception of the legality of nature. Starting from the comparison of his concept of "providence" with that of Spinoza and Boyle, it turned out that the greater similarity of thought would be with Boyle. Huygens seems to endorse the re-elaboration of the Christian notion of providence made by the English scientist from the Roman stoicism of Cicero and Seneca (Harwood 1991). Furthermore, he seems to share Boyle's mature thought regarding the relationship between natural philosophy and theology in which an "epistemology of the limit" is sketched out (Pacchi 1973, 244). In Huygens, the insistence on the limits of human reason and on the need to renounce a rational foundation of metaphysics can be found in many of his last writings and it has Descartes as its first critical goal.²⁰ Moreover, human beings' awareness of their "imbecillitas"²¹ (namely mental and physical weakness), combined with the desire to preserve their lives, would be the incentive to join others in a society governed by laws of nature. In my view, these considerations show a component of rational cosmopolitanism based on stoic philosophy that, following the idea of a common human nature, may include the Dutch scientist among those thinkers of the doctrine of natural law.²² Therefore, these results might be able to reduce the importance of the moral libertarianism and scepticism that would influence Huygens in his Paris years, as some scholars have sustained (Gori 1976, Vilain 1996).

The recovery of Huygens' philosophical sources has been possible only thanks to a textual comparison between fragments of his different texts and then with that of other philosopher-scientists. Firstly, I interpreted the meaning variations of each *concept-lemma* and, secondly, I followed the research paths suggested by critical literature. I took into account some studies that have proposed comparison between the thought of Huygens and that of some "real" contemporaries. Above all, I tried to support Alfred R. Hall's thesis according to which Huygens should not be compared only with Leibniz and Newton, since they belong to a further generation less tied to Descartes' authority (Hall 1980, 303). I indeed considered and tried to reply to those studies that have indicated possible influences and

¹⁸ OC 21, *Cosmotheoros I*, 759; *Cosmotheoros II*, 787 and 789; *Verisimilia de planetis*, 543 and 554.

¹⁹ OC 21, *Préface del Discours de la cause de la pensanteur*, 436.

²⁰ Especially in OC 21, *Appendice aux pièces 'De rationi imperviis'* etc., 524–28.

²¹ OC 21, *Cosmotheoros I*, 743; OC 21, *De probatione ex verisimili*, 541.

²² OC 21, *Cosmotheoros I*, 749; OC 21, *Quod animalium productio*, § 8; OC 21, *Verisimilia de Planetis*, §§ 12, 15, 23.

similarities with Spinoza (Parrochia 1984, Klever 1997) and Boyle (Hall M.B. 1980, Snelders 1980, Chareix 2008 and 2009) but focusing only on Huygens' scientific works. Instead, in the case of Locke, my research opens a new perspective still unexamined by historians of science and philosophy.

Final Remarks and Perspective on Digital Humanities

My research methodology consisting of a preliminary digital text analysis enabled an objective exploration and lexicographical comparison, never before done, of two corpora: Huygens' late writings and correspondence. During the first step of the data quantitative analysis, I was able to use the *AntConc* tool to process a large number of texts without any previous knowledge of their content and to obtain information related to the word frequencies and key words in the five languages. Based on this quantitative data, I was able to select the terms that seemed the most interesting by looking through their concordance lists and interpreting their co-texts. Therefore, the second step of qualitative analysis allowed me to find other relevant and related terms, which each time I checked for their frequency and collocations count. This entailed going back to the first phase and so on until the terms were able to fulfil my analytical needs. From this point of view, it means that the two quantitative and qualitative approaches, even though separated into two different phases, are extremely connected and complementary in the extraction of new knowledge from texts. The final choice of each *concept-lemma* to be interpreted was a wager, a hypothesis that might be evaluated only at the end of the juxtaposition and analysis process of the text fragments whose common thread consisted of each *Key Word in Context*. Nevertheless, we can recognize that this computational "corpus-based" approach allowed a wide scope of exploration that led to the achievement of some relevant insights into the history of ideas of the seventeenth century, which were – as I hoped – not predictable in advance.

Many research perspectives based on this preliminary digital analysis might be pursued. Firstly, several other conceptual words could be analysed, paying particular attention to those co-occurrences that are common to a number of word clusters. In this regard, it would be useful to use a data visualization tool able to display any repetition of collocations and co-occurrences in the word clusters so that one can see more effectively when a repeated term may be considered as the same "conceptual association" between key words. Subsequently, it would be possible and extremely useful to build a terminological database or electronic thesaurus, based on conceptual-semantic and lexical associations (on the example of WordNet) also from a diachronic perspective, for each author computationally analysed. This could eventually lead to a mapping of conceptual associations not only between an author's works in different years but also between different authors who were involved in the same theoretical debate.

Bibliography

Primary sources

Huygens, Christiaan, *Œuvres complètes de Christiaan Huygens publiées par la Société Hollandaise des Sciences*, 22 voll., The Hague: M. Nijhoff, 1888–1950.

Secondary sources

Andriessse, Cornelis D., *Titan kan niet slapen. Een biografie van Christiaan Huygens*. Amsterdam: Contact, 1993.

Anthony, Laurence, “A Critical Look at Software tools in Corpus Linguistics”. *Linguistic Research* 30, n. 2 (2013), 141–161 [online at: <http://www.laurenceanthony.net/publications.html>].

Bertoloni Meli, Domenico, *Thinking with Objects. The Transformation of Mechanics in the Seventeenth Century*. Baltimore: The Johns Hopkins University Press, 2006.

Bos, Hendrik J. M., “L’œuvre et la personnalité de Christiaan Huygens”, in *Huygens et la France, table ronde du CNRS*, Paris 27-29 mars 1979, edited by René Taton, 1–15. Paris: Vrin, 1982.

Burch, Christopher, “Huygens’ Pulse Models as a Bridge between Phenomena and Huygens’ Mechanical Foundations”. *Janus* 68, (1981), 53–64.

Burns, Robert M., *The Great Debate on Miracles: From Joseph Glanvill to David Hume*. Lewisburg (PA): Bucknell University Press, 1981.

Cassirer, Ernst, *Das Erkenntnisproblem in der Philosophie und Wissenschaft der neueren Zeit*, vol. II. Berlin: B. Cassirer, 1907.

Chareix, Fabien, “Experientia ac ratio: L’œuvre de Christiaan Huygens”. *Revue d’histoire des sciences* 56, n. 1 (2003), 5–13.

—, “Le rationnel et le raisonnable. Sur un manuscrit de Christiaan Huygens: le De Rationi Imperuijs (1690)”, in *Le savoir au XVIIe siècle*, edited by J. Lyons and C. Welch, Biblio 17–147, 335–44. Tübingen: Gunter Narr Verlag, 2003a.

—, “L’Académie des ‘chimiques’ et des ‘mécaniques’: l’évolution de la chimie dans la pensée de Huygens”. *Methodos* 8, 2008 [online at: <http://methodos.revues.org/1343>].

—, “Christiaan Huygens lecteur de Robert Boyle”, in *La philosophie naturelle de Robert Boyle*, edited by M. Dennehy-C. Ramond, 311–29. Paris: Vrin, 2009.

Chiari, Isabella, *Introduzione alla linguistica computazionale*. Roma-Bari: Laterza, 2007.

De Mauro, Tullio, “Quantità-qualità: un binomio indispensabile per comprendere il linguaggio”, in *Ricerca qualitativa e computer*, edited by R. Cipriani and S. Bolasco, 21–30. Milano: FrancoAngeli, 1995.

Elzinga, Aant, *On a Research Program in Early Modern Physics*. Göteborg: Akademiförlaget, 1972.

—, “Christiaan Huygens’ theory of research”. *Janus* 67, 1980, 281–300.

Froehlich, Heather, “Corpus analysis with AntConc”. *Programming Historian*, 2015 [online at: <https://programminghistorian.org/lessons/corpus-analysis-with-antconc>]

Funkenstein, Amos, *Theology and the Scientific Imagination from the Middle Ages to the Seventeenth Century*. Princeton: Princeton University Press, 1986.

Gabbey, Alan, “Huygens and Mechanics”, in *Studies on Christiaan Huygens, invited Papers from Symposium on the Life and Work of Christiaan Huygens*. Amsterdam, 22-25 August 1979, edited by Hendrik J. M. Bos *et al.*, 166–99. Lisse: Swets & Zeitlinger, 1980.

Gori, Gianbattista, “La filosofia in Olanda da Geulincx ad Huygens”, in *Storia della filosofia*, edited by M. Dal Pra, 595–612. Firenze: Vallardi, 1976.

Gregory, Tullio, *Origini della terminologia filosofica moderna. Linee di ricerca*. Firenze: Leo S. Olschki, 2006.

Hall, Alfred R., “Summary of the Symposium”, in *Studies on Christiaan Huygens, invited Papers from Symposium on the Life and Work of Christiaan Huygens*. Amsterdam, 22-25 August 1979, edited by Hendrik J. M. Bos *et alia*, 302–313. Lisse: Swets & Zeitlinger, 1980.

Harrison, Peter, *The Bible, Protestantism, and the Rise of Natural Science*. Cambridge: Cambridge University Press, 1998.

Harwood, John T., *The Early Essays and Ethics of Robert Boyle*. Carbondale and Edwardsville: Southern Illinois University Press, 1991.

Hoey, Michael, *Lexical Priming: A New Theory of Words and Language*. London: Routledge, 2005.

Hohenegger, Hansmichael, “Termini tecnici e traduzione. Note sulla traduzione della Critica della Facoltà di Giudizio di Kant”, in *Tradurre filosofia. Esperienze di traduzione di testi filosofici del Seicento e del Settecento*, edited by Pina Totaro, 59–92. Firenze: Leo S. Olschki, 2011.

Hooykaas, Reijer, *Experientia ac ratione. Huygens tussen Descartes en Newton*, Mededeling, 201. Leiden: Museum Boerhaave, 1979.

Klever, Wim, “Spinoza en Huygens. Een geschakeerde relatie tussen twee fysici”. *Gewina* 20, 1997, 14–31.

Koyré, Alexandre, *Metaphysics and Measurement. Essays in Scientific Revolution*. Cambridge: Harvard University Press, 1968.

Mach, Ernst, *Die Mechanik in ihrer Entwicklung historisch-kritisch dargestellt*. Leipzig: Brockhaus, 1883.

Mormino, Gianfranco, *Penetralia motus: la fondazione relativistica della meccanica in Christiaan Huygens*. Firenze: La Nuova Italia, 1993.

—, “Atomismo e meccanicismo nel pensiero di Christiaan Huygens”, in *Spazio, corpo e moto nella filosofia naturale del Seicento*, 63–109. Milano-Udine: Mimesis, 2012.

—, “Ammirare e comprendere. La concezione del sapere in Christiaan Huygens”, in *«Potentia Dei»: l’onnipotenza divina nel pensiero dei secoli XVI e XVII*, edited by G. Canziani-M.A. Granada-Y.C. Zarka, 495–511. Milano: Franco Angeli, 2000.

—, “Le rôle de Dieu dans l’œuvre scientifique et philosophique de Christiaan Huygens”. *Revue d’histoire des sciences* 56, n. 1 (2003), 113–33.

—, “Sur quelques problèmes éditoriaux concernant l’œuvres de Christiaan Huygens”. *Revue d’histoire des sciences* 56, n. 1 (2003), 145–151.

Pacchi, Arrigo, *Cartesio in Inghilterra: da More a Boyle*. Roma-Bari: Laterza, 1973.

Parrochia, Daniel, “Optique, Mécanique et Calcul des Chances chez Huygens et Spinoza”. *Dialectica* 38 (1984), 319–345.

Radelet De Grave, Patricia, “L’Univers selon Huygens, le connu et l’imaginé”. *Revue d’histoire des sciences* 56, 1 (2003), 79–112.

Romein, Jan and Annie, *Erflaters van onze beschaving: Nederlandse gestalten uit zes eeuwen*. Amsterdam: Querido, 1977.

Russo, Ada, “Il lessico dei lessici: una ontologia per i lessici filosofici latini”, in *Lessici filosofici dell’età moderna. Linee di ricerca*, edited by E. Canone, 171–99. Firenze: Leo S. Olschki, 2012.

Snelders, Henricus A. M., “Christiaan Huygens and the concept of matter”, in *Studies on Christiaan Huygens: invited papers from the symposium on the life and work of C. Huygens*, Amsterdam, 22-25 aug. 1979, edited by H. J. M. Bos *et al.*, 104–25. Lisse: Swets & Zeitlinger, 1980.

Sinclair, John, *Corpus, Concordance, Collocation*. Oxford: Oxford University Press, 1991.

Tognini-Bonelli, Elena, *Corpus Linguistics at Work*. Amsterdam: John Benjamins Publishing, 2001.

Vermij, Rienk, *The Calvinist Copernicans. The Reception of the New Astronomy in the Dutch Republic. 1575-1750*. Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen, 2002.

Vilain, Christiane, *La mécanique de Christiaan Huygens: la relativité du mouvement au XVIIe siècle*. Paris: Blancard, 1996.

Westfall, Richard S., *Force in Newton’s Physics: the Science of Dynamics in the Seventeenth Century*. London: Macdonald, 1971.

Watson Todd, Richard, “Identifying New Knowledge in Texts through Corpus Analysis”. *International Journal of Language Studies* 7, n. 4, Oct. 2013, 57–76.

Yoder, Joella G., “The Archives of Christiaan Huygens and his Editors”, in *Archives of the Scientific Revolution: The Formation and Exchange of Ideas in Seventeenth-century Europe*, edited by M. C. W. Hunter, 91–107. Woolbridge: Boydell & Brewer, 1998.

—, *Catalogue of the Manuscripts of Christiaan Huygens: Including a Concordance with his Œuvres completes*. Leiden: Brill, 2013.

Digital Resourcesⁱ

L. Anthony, AntConc (Version 3.4.3) [Computer Software]. Tokyo: Waseda University, 2014.
www.laurenceanthony.net/software/antconc

Digitale bibliotheek voor de Nederlandse letteren, Uitgaven van Christiaan Huygens
www.dbnl.org/auteurs/auteur.php?id=huyg003

ePistolarium, Huygens ING, Developed by Walter Ravenek
<http://ckcc.huygens.knaw.nl/epistolarium>

The Works of John Locke in Nine Volumes, Online Library of Liberty
<http://oll.libertyfund.org/titles/locke-the-works-of-john-locke-in-nine-volumes>

Early Modern Letter Online (EMLO)
<http://emlo.bodleian.ox.ac.uk/home>

Banca dati di testi filosofici dell'età moderna, Lessico Intellettuale Europeo e Storia delle Idee (ILIESI-CNR) <http://lie11.let.uniroma1.it:8777/iliesi/home.htm>

Daphnet Modern Philosophy, ILIESI-CNR
www.daphnet.org

Lessici filosofici di età moderna, ILIESI-CNR
www.iliesi.cnr.it/Lessici

Centre National de Ressources Textuelles et Lexicales
www.cnrtl.fr/portail

Trésor de la Langue Française informatisé, Analyse et Traitement Informatique de la Langue Française
www.atilf.fr/tlfi

ⁱ Last consultation: 22/08/2017.