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LEIBNIZ, WEIGEL AND THE BIRTH OF BINARY ARITHMETIC*

ABSTRACT: In recent years, Leibniz's previously unpublished writings have cast a new light on his relationship with Erhard Weigel, from a mere influence during the early years to an exchange of ideas that lasted at least until Weigel's death in 1699. In this paper I argue that Weigel's *De supputatione multitudinis a nullitate per unitates finitas in infinitum collineantis ad deum* is one of the most important influences on Leibniz's development of binary arithmetic. This work published in 1679, the same year of Leibniz's *De progressione dyadica*, contains some fundamental ideas adopted by Leibniz both in mathematics and metaphysics. The controversial theories expressed in these writings will also help in understanding why Leibniz tried to hide Weigel's influence during his life.

SOMMARIO: In questi anni, a seguito della pubblicazione degli scritti inediti di Leibniz, è emersa con maggior chiarezza l'importanza del suo rapporto con Erhard Weigel, suggerendo un'influenza che non si limita al periodo di formazione a Jena, ma che tiene anche in considerazione gli anni successivi, fino alla morte di Weigel nel 1699. In questo articolo viene mostrato come l'opera di Weigel, intitolata *De supputatione multitudinis a nullitate per unitates finitas in infinitum collineantis ad deum*, possa essere considerata come uno dei testi fondamentali che hanno influenzato Leibniz nello sviluppo dell'aritmetica binaria. Pubblicata nel 1679, lo stesso anno in cui Leibniz scrisse il *De progressione dyadica*, quest'opera contiene alcune idee fondamentali che Leibniz decise di adottare, sia in ambito matematico, sia in ambito metafisico. Le controverse teorie esposte

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in questi scritti aiuteranno inoltre a esprimere un'ipotesi ragionevole sul perché Leibniz tentò di nascondere in vita l'influenza di Weigel sul suo pensiero.

KEYWORDS: Binary arithmetic; Dyadic; Philosophy of Mathematics; Erhard Weigel

1. *Introduction*

Erhard Weigel was Leibniz's teacher in mathematics and metaphysics during the semester that Leibniz spent in Jena in 1663.[1] He is generally considered an important influence on the philosophy of the young Leibniz and its development, but this importance is somehow lost in the outstanding number of authors that Leibniz managed to read during his early years, making it difficult to understand its exact extent. Some interpreters[2] focus on Weigel's influence in specific topics, such as the endorsement of Aristotelic ideas, the mathematization of reality or logical reasoning, but a complete reconstruction of the relationship between Weigel and Leibniz is still missing.

Recently, the secondary literature is focusing more and more on this relationship, with rather interesting results: it can be proved that Leibniz extensively read Weigel's works not only at the beginning of his philosophical career but also throughout his whole life.[3] The fact that this intercourse should not lead to the acknowledgment of Weigel's importance

[1] For a reconstruction of Leibniz's life and his first meeting with Weigel see M. R. Antognazza, *Leibniz: an intellectual biography*, Cambridge, Cambridge University Press, 2009, p. 58-59.

[2] On the problem of identifying Weigel's exact influence on the young Leibniz see F. Piro, *Varietas identitate compensata: studio sulla formazione metafisica di Leibniz*, Napoli, Bibliopolis, 1990, but also F. Piro, "*Species infima*. Definibilità e indefinibilità dell'individuo", in B. M. d'Ippolito, A. Montano, F. Piro (ed.), *Monadi e monadologie. Il mondo degli individui tra Bruno, Leibniz e Husserl. Atti del Convegno Internazionale di Studi [Salerno, 10-12 giugno 2004]*, Soveria Mannelli, Rubbettino Editore, 2005, p. 83-113 for a criticism on an easy identification of Weigel's thesis with those contained at the end of Leibniz's *Disputatio metaphysica de principio individui*. On the same topic see also C. Mercer, *Leibniz's Metaphysics: Its Origins and Development*, Cambridge, Cambridge k University Press, 2002. One of the most important books dedicated to Leibniz and Weigel is K. Moll, *Der junge Leibniz, Bd. I: Die wissenschaftstheoretische Problemstellung seines ersten Systementwurf. Der Anschluss an Erhard Weigel*, Stuttgart-Bad, Frommann-Holzboog, 1978. On the influence in Leibniz's logic, a recent paper is M. Bullynck, "Erhard Weigel's Contributions to the Formation of Symbolic Logic", *History and Philosophy of Logic*, 34 (1), 2013, p. 25-34.

[3] See M. Palumbo, "'Praeceptor, Fautorque meus colendus…' – Weigels Werke in der Privatbibliothek von Leibniz", in K. Habermann-K.-D. Herbst (ed.), *Erhard Weigel (1625-1699) und seine Schüler. Beiträge des 7. Erhard-Weigel-Kolloquiums 2014*, Göttingen, Universitätsverlag Göttingen 2016, p. 249-268.

at a later time is perhaps influenced by Leibniz himself, who in a letter to Christian Philipp dated March 1681 shares this opinion on him:

> Mons. Weigelius a beaucoup d'esprit sans doute; mais souvent il est peu intelligible, et il semble qu'il n'a pas tousjours des pensées bien nettes. Je voudrois qu'il s'appliquât plus tost à nous donner quantité de belles observations, qu'il a pû faire en practiquant les mecaniques, que de s'amuser à des raisonnemens generaux, où il me semble qu'il se perd quelques fois. Non obstant tout cela je ne laisse pas de l'estimer beaucoup; et de reconnoistre qu'il se trouve beaucoup de bonnes pensées dans tous ses écrits.[4]

This is a perfect example of Leibniz's general and ambiguous attitude towards Weigel: on one hand he prises some of Weigel's ideas and, on the other hand he acts as if he is judging them from a distance, without explicitly recognising their direct influence on his philosophy. As Leibniz remarked, being a philosopher who establishes a perfect connection between metaphysics, ontology, physics and human knowledge, Weigel may appear confusing, especially since his style somehow tries to express all these relationships at the same time, but this difficulty shouldn't sway us from our purpose of identifying the exact extent of his influence.

Following this purpose, in this paper I will argue that Weigel played a fundamental role in Leibniz's development of binary arithmetic, especially at the very beginning of Leibniz's reflections on this topic in 1679. I believe that the outcome of this confrontation could prove itself extremely useful for understanding some intricacies that were always related to binary arithmetic in Leibniz: its relation with the other parts of Leibniz's philosophy and their development in time, or its enigmatic use both as a mathematical and a metaphysical tool. The outcome of this analysis will be that Leibniz has not developed binary arithmetic as a mere mathematical tool and then applied it to metaphysics only at a later time. Since the very beginning he was in fact influenced by Weigel's *De supputatione multitudinis a nullitate per unitates finitas in infinitum collineantis ad deum*. This work already embeds some of the most important features of Leibniz's binary arithmetic, both from the mathematical and metaphysical point of view. It also helps us in understanding why and how the topic of binary arithmetic could be related to the topic of *analysis situs*, which had a

[4] G. W. Leibniz, *Sämtliche Schriften und Briefe*, Darmstadt-Leipzig-Berlin, Akademie der Wissenschaften (Akademieausgabe), 1923-, collected in 8 Series, each one divided in several volumes, II-1, p. 815.

fundamental evolution in the same year in which Leibniz developed his binary system.

As a starting point, in the first section I will outline the correspondence between Weigel and Leibniz in 1679, in order to point out the importance of Weigel's *De supputatione* in the light of a Pythagorean influence and a possible connection between the ideas expressed in the letters and binary arithmetic. In the second section, I will offer a brief introduction on Leibniz's binary arithmetic, focusing on some important concepts spread throughout his writings, and a thorough analysis of Weigel's *De supputatione*. The exact correspondence between Leibniz's and Weigel's ideas will lead us to recognize Weigel as one of the main influences in the development of Leibniz's arithmetic. Ultimately, the analysis of these topics will help us to express a reasonable hypothesis on why Leibniz tried to hide Weigel's influence during his life.

2. *The confrontation with Weigel in 1679*

The topic of a supposed influence of Weigel on Leibniz's development of binary arithmetic is rather old and dates back to Couturat's *La logique de Leibniz*. In this book Couturat argues with an impressive intuition, given the availability of primary sources at that time, that Leibniz was influenced by Weigel's *Tetractys*, a work published in 1673 which explains a way of counting in a base-four system, instead of the usual base-ten one. Couturat's reasoning is simple: since the first writing on binary arithmetic in Leibniz, *De progressione dyadica*, is dated 15 March 1679, it could be that Leibniz took the idea of changing the base and then applied it to his base-two system. This interpretation is justified by a kind of accusation formulated by Johann Bernoulli in a letter dated 11 April 1701 in which he outlines the similarities between the two systems, more than Couturat's actual research on Weigel.[5] In a letter dated 20 April 1701, Leibniz replies

[5] In the *Logique* we read: "son Arithmétique dyadique ou sa numération binaire. Il importe de donner un peu plus de détails sur celle-ci. On a vu que Leibniz avait été amené à cette invention par la recherche d'une notation aussi claire et aussi adéquate que possible pour les nombres. Elle lui avait été probablement suggérée par la *Tetractys* de son ancien maître Weigel, publiée en 1673. Leibniz n'approuvait pas ce système de numération a base 4, qui n'avait aucune raison d'être" and again in the related footnote: "Pourtant Leibniz prétendait plus tard avoir inventé sa Dyadique avant la *Tetractys* de Weigel. Peut-être sa mémoire le trompait-elle, ou s'exagérait-il son originalité; peut-être aussi l'idée première lui avait-elle été suggérée, non par le livre, mais par l'enseignement de son maitre : *Lettre à Jean Bernoulli*, 29 avril 1701: 'Molitus hoc sum ante multos annos, etiam antequam

that, even if the similarities could be perceived, he started his reflections on these topics many years before he read Weigel's works. On a side note, he also adds that his system is much more useful than the one explained by Weigel, because there is no real reason for a human being to change his way of counting from a base-ten model to a base-four one, whereas the base-two model follows the idea of simplicity, since only the digit 1 and the digit 0 are used. At the same time, Leibniz's system shows in his opinion a better way to express some proprieties that pertain numbers in general and their progression. Despite Leibniz's efforts in pointing out the originality of his theory, it seems that the idea of a decisive influence by Weigel was shared between Bernoulli's brothers, as a letter from Jakob Bernoulli dated 28 February 1705 shows: "De mysterio Arithmeticae Tuae Dyadicae (quam video esse supplementum Tetractys Weigelianae) nihil adhuc mihi innotuerat".[6]

The topic of understanding Weigel's influence then seems to be reduced to whether believe or not in Leibniz when he says that he was not aware of Weigel's writings at the time of the birth of binary arithmetic. Another take on this problem is that of Gaston Grua, who argues that Couturat mistook Weigel's *Aretologistica* with the *Tetractys*: "La *Tetractys* classe les êtres par quatre. L'invention du calcul binaire le 15 mars 1679 ne lui doit rien, malgré COUT. Op. 278, qui a confundu cet ouvrage avec le premier exposé de la numération quaternaire, en 1687, en appendice à l'*Aretologistica*".[7] Grua bases his assumptions on a passage from Leibniz's *Animadversiones ad Weigelium*:

> Atque hoc nunc quidem ad *Speculum* Viennese breviter notare placuit; praesertim cum nondum antea mihi fuerit lectus hic liber, non magis quam alter Aretologisticus, qui longius etiam sese in res metaphysicas diffundit [...]. Quod tetractycam arithmeticen attinet, arbitror in praxi si quid mutandum esset potius duodecimalem vel sedecimalem fore adhibendam pro decimali; quo majoris enim numeri progressio adhibentur (dummodo tabulae Pythagoricae fundamentales memoria teneantur) eo expeditior est calculus [...] puto non tantum tertactycam

quicquam constaret de Tetracty illa nuper ressuscitata (Math, III, B, 2)'" (See L. Couturat, *La logique de Leibniz : d'apres des documents inédits,* Paris, F. Alcan, 1901, p. 473). As for Bernoulli and Leibniz's correspondence on this topic see the forthcoming Leibniz, *Sämtliche Schriften und Briefe*, III-8.

[6] G. W. Leibniz, *Leibnizes mathematische Schriften*, ed. C. I. Gerhardt, Hildesheim-New York, Georg Olms Verlag, 1971, vol. III, p. 96.

[7] See G. W. Leibniz, *Textes inédits d'après les manuscrits de la Bibliothèque provinciale de Hanovre*, ed. G. Grua, Paris, Presses Universitaires de France, 1948, Tome I, p. 330.

> decimali esse praeferendam; sed et ipsi teractycae rursus praeferendam esse dyadicam, quae omnium perfectissima est.[8]

Both Couturat's and Grua's theories are somehow defective for different reasons. We cannot prove with Couturat that Leibniz read the *Tetractys* before 1679, because Leibniz's first references to this work are notes taken in 1683, after the birth of the calculus.[9] But, Grua's assumption that Weigel's first writing on a base-four model is the *Aretologistica*, dated 1687 i.e. after Leibniz's *De progressione dyadica*, is based on a mistake.[10] Around 1673 Weigel published not one, but two different works, one entitled *Tetractyn tetracty pythagoreae correspondentem*, and the other one entitled *Tetractys Summum tum Arithmeticae tum Philosophiae discursivae Compendium*. If it is true that the former work, the one that was probably verified by Grua, deals only with the general ideas related to the *tetractys*, the latter contains a base-four model very similar to that of the 1687's *Aretologistica*.[11]

The reconstruction of these interpretations however leads us to an important result: even if it is highly doubtful, we could still believe Leibniz when he declares to Bernoulli that he was not influenced by Weigel's *Tetractys*. In fact, we could still believe that he was referring only to the specific work entitled *Tetractys* and assume that Leibniz's notes on it dated 1683 correspond also to the first moment in which he actually read it. But the same thing cannot be said for the reference to Weigel in the *Animadversiones ad Weigelium*, because in this work Leibniz deals with Weigel's base-four system in general. The *Animadversiones* are in fact dated

[8] G. W. Leibniz, *Nouvelles lettres et opuscules inédits de Leibniz*, ed. A. Foucher de Careil, Paris, 1857, p. 164-166.

[9] See Leibniz, *Sämtliche Schriften und Briefe*, VI-4B, p. 1162. Around 1683 (the exact date is uncertain) Leibniz reads and annotates several writings published by Weigel in 1673: the *Tetractys, summum tum arithmeticae tum philosophiae discursivae compendium artis magnae sciendi genuina radix* and the *Tetractyn Pythagoreae corrspondentem ut* PRIMUM *disceptationum suarum specimen ulteriori curiosorum industria exponit Societas Pythagorea,* but also the *Methodus discendi nov-antiqua*, the *Universi corporis Pansophici caput summum a rebus naturalibus moralibus et notionalibus denominativo simul et aestimativo gradu cognoscendis abstractum* and the *Corporis pansophici pantologia*. These works are particularly interesting for Leibniz's development of his *analysis situs*.

[10] This mistake is also made in other reconstructions of the history of binary arithmetic, for example in A. Glaser, *History of binary and other nondecimal numeration*, Pennsylvania, Tomash Publishers, 1981. Another take against Weigel's influence on the birth of binary arithmetic is found in H. H. Knecht, *La logique chez Leibniz. Essai sur le rationalisme baroque*, Lausanne, L'Age d'Homme, 1981, p. 28.

[11] See E. Weigel, *Tetractys summum tum arithmeticae tum philosophiae discursivae compendium, artis mangnae sciendi genuina radix*, Jena, Sumptibus Johannis Meyeri, Typis Wertheriani, 1673, p. 15-24.

1690 and at that time Leibniz already read the *Tetractys* and several other works by Weigel, included his *De supputatione*, as we will soon prove. In other words, it seems somehow suspicious that in the *Animadversiones* Leibniz, after so many reads on Weigel, feels the need of quoting the *Aretologistica*, an obscure and confusing work in German, published many years after the first writings on this topic, while he was perfectly aware of Weigel's earlier and more important essays written in Latin. It is as if Leibniz wanted to divert the attention from the similarities between him and Weigel. I believe that this is a key factor in determining the extent of Weigel's influence, because it suggests that perhaps there are more similarities than the ones generally recognised. The older interpretations are based in fact only on a supposed influence on the idea of changing the base system and on the operations derived from this change, but I would like to argue that Weigel's influence is much deeper and it has its roots also in the metaphysical background related to binary arithmetic.

The first step in this direction is the analysis of Leibniz's and Weigel's correspondence. It seems that everything revolves around year 1679, the fated year of Leibniz's *De progressione dyadica*, and it is not a coincidence that the first letter to Weigel was sent by Leibniz in the same year, in September. This letter starts with an extremely useful information for our purposes:

> Dissertationem tuam *de supputatione* legi non sine magna animi voluptate et quod eam mittere voluisti gratias ago. Quanquam enim nonnulla non satis assequerer, multa tamen notavi praeclara et profunda. Eaque occasione Tibi proponam observationem meam quae ad institutum tuum (tractas enim ut in titulo habes *de supputatione multitudinis a nullitate per unitates finitas in infinitum collineantis ad Deum*) pertinere nonnihil videtur.[12]

In this passage we can infer that in September 1679 Leibniz already read Weigel's *De supputatione*, but also that we don't know the beginning of this correspondence, that is Weigel's first letter, or something similar, in which he attached his work. Given that, this work contains many similarities with Leibniz's writings on binary arithmetic, determining if Leibniz received it before the 15th of March 1679 could also determine if Leibniz was directly influenced by Weigel on this topic in that year. Unfortunately, there is no way to retrieve this information, but further observations are needed. Weigel's *De supputatione* could have been published before the 15th of March 1679, plus it wouldn't be the first time in which Leibniz is aware of

[12] Leibniz, *Sämtliche Schriften und Briefe*, II-1B, p. 745.

a work written by Weigel before its actual publication, even more considering that at that time Weigel already had a high opinion of his disciple.[13] Also, Leibniz's letter seems at least unusual: it starts with this reference to Weigel's work but, given that few months before Leibniz already developed his binary arithmetic, one would think that the observations Leibniz wants to make are going to be a brief exposition of this theory, in order to celebrate the affinity with his teacher's ideas. Surprisingly, there is no mention of his binary arithmetic in this letter, replaced instead with an exposition on peculiar proprieties pertaining some number series. Besides, this is not a letter with no philosophical or mathematical content, since, aside from the aforementioned number series, there are also references to Leibniz's 1672 *Accessio ad Arithmeticam Infinitorum* and to his recently developed *characteristica geometrica*.[14]

By no means the observation on number series is not consistent with the topics of the *De supputatione*, as Leibniz himself writes, because the number series chosen are built through a continuous addition of unities in order to generate the series of natural numbers, the series of triangular numbers and the series of pyramidal numbers. These series are similar to the Pythagorean ideas expressed in Weigel's *De supputatione*, because they suggest the possibility of expressing geometrical dimensions through the repetition of a simple unity. However, if this was Leibniz's aim, the absence of a theory, such that of binary arithmetic, representing so well the idea of a constitution of the world through unity and zero couldn't be a mere coincidence.

The analysis of the exchange between Weigel and Leibniz then suggests that a study on the ideas and terminology used in their 1679's

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[13] In a letter to Hermann Conring dated April 1670 we read: "Audio et Cl. V. Erhardum Weigelium, libello de aestimatione mox prodituro, plurima ex jure nostro, quae ad quantitates gradusque voluntatis, scientiae, diligentiae, malitiae, poenae, damni, certitudinis, praesumtionis, probabilitatis, aliorumque, quorum in re morali crebra mentio est, delibaturum" (Leibniz, *Sämtliche Schriften und Briefe*, II-1, p. 70). The reference is probably to Weigel's *Universi corporis pansophici caput summum*, a work that will be published three years after this letter. It is particularly relevant for two reasons: it is a work in which some important ideas related to the *Tetractys* are already present and it is one of the work analysed by Leibniz in 1683, casting a lot of doubts on the hypothesis that those notes could testify that those works, *Tetractys* included, were read by Leibniz for the first time in 1683. About Weigel's appreciation for Leibniz, the very last sentence of Weigel's *Corollaria* in his *Pendulum ex tetracy deductum…sistit* is: "Speciosa est hypothesis Leibnüziana, quae bullulis pleraque Phaenomena Corporum salvare docet" (E. Weigel, *Pendulum ex tetracy deductum…sistit*, Jena, Typis Johannis Wertheri, 1674).

[14] Leibniz, *Sämtliche Schriften und Briefe*, II-1B, p. 745 n., 747 n.

writings is needed in order to compensate for the lack of information on the reception of Weigel's *De supputatione*.

3. De organo sive arte magna cogitandi *in the light of Weigel's* De supputatione

Retracing the influences of other authors in Leibniz's four-page manuscript *De progressione dyadic*a is not an easy task: Leibniz presents here nothing more than the operations needed in his binary calculus (addition, subtraction and the like) and the hypothesis for a machine built on these principles. Perhaps the only hint we could find in this work is a reference to the multiplication table, called table of Pythagoras, that here is quoted two times.[15] It tells us that one of the main topics involved in the development of the calculus is the possibility of simplifying operations or completely avoiding the use of such tables. This topic is consistent with what Leibniz writes in the *Animadversiones ad Weigelium*, in which he points out, quoting again the table of Pythagoras, how the use of Weigel's four-base model does not help much in this effort, as we already showed.

Thankfully, Leibniz's *De organo sive arte magna cogitandi*, written around the same time of his *progressione dyadica*, gives us a better understanding of Weigel's influence. In this work Leibniz associates for the first time his binary calculus to the metaphysical relationship between unity and nothingness:

> Fieri potest, ut non nisi unicum sit quod per se concipitur, nimirum Deus ipse, et praeterea nihilum seu privatio, quod admirabili similitudine declarabo. Numeros vulgo explicamus per progressionem decadicam, ita ut cum ad decem pervenimus, rursus ab unitate incipiamus, quam commode id factum sit nunc non disputo; illud interea ostendam, potuisse ejus loco adhiberi progressionem dyadicam, ut statim ubi ad binarium pervenimus rursus ab unitate incipiamus [...] Immensos hujus progressionis usus nunc non attingo: illud suffecerit annotare quam mirabili ratione hoc modo omnes numeri per unitatem et nihilum exprimantur.[16]

This relationship, displayed at such an early stage in the history of binary arithmetic, proves that since its beginning Leibniz develops the mathematical achievements together with the metaphysical ones. Following the platonic tradition, Leibniz conceives nothingness as non-existence, as a tool that helps shaping the world, but what he adds is that the role of nothingness resembles the role of the mathematical zero,

[15] See G. W. Leibniz, LH 35, 3b 2 Bl, p. 1, 3.

[16] Leibniz, *Sämtliche Schriften und Briefe*, VI-4A, p. 158.

whereas the role of existence, both God and creature's kind of existence, resembles the role of the mathematical unity. It follows that binary arithmetic is also somehow connected to the idea of an essential limitation pertaining creatures,[17] to the problem of distinguishing the unity expressed by God from that of such creatures and to the true nature of nothingness, both as an absolute concept and as something that can be conceived only together with something else.

After this work, evidences of this reasoning are spread all over Leibniz's production about binary arithmetic. In the 1695 *Dialogue effectif sur la liberté de l'homme et l'origine du mal*, after having introduced the concept of nothingness, to the question on how nothingness is capable of entering in the composition of things, Leibniz replies: "vous savez pourtant comment dans l'Arithmétique les zero joints aux unités, font des nombres differens comme 10, 100, 1000 [...] et il e nest de même de toutes les autres choses, car ells sont bornées ou imparfaites par le principe de la Negation ou du Neant qu'elles renferment".[18] Here we have both the use of unities and zero in a composition and the idea of a priority of unity over zero, which resembles closely the priority of existence over non-existence. Three years after this dialogue, in a letter to Schulenburg dated 29 March 1698, the bond with essential limitation is even stronger:

> Nimirum fines seu limites sunt de Essentia Creaturarum, limites autem sunt aliquid privativum, consistuntque in negatione progressus ulterioris. Interim fatendum est, creaturam, postquam jam valorem a Deo nacta est, qualisque in sensus incurrit, aliquid etiam positivum continere, seu aliquid habere ultra fines neque adeo in meros limites seu indivisibilia posse resolve [...] Atque haec est origo rerum ex Deo et nihilo, positivo et privativo, perfectione et imperfectione, valore et limitibus, activo et passivo, forma (id est entelechia, nisu, vigore) et materia seu mole, per se torpente nisi quod resistentiam habet. Illustravi ista nonnihil origine numerorum ex 0 et 1 a me observata, quae pulcherrimum est emblema perpetuae rerum creationis ex nihilo, dependentiaeque a Deo.[19]

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[17] On this topic see M. Fichant, "L'origine de la négation", in Id., *Science et métaphysique dans Descartes et Leibniz*, Paris, Presses Universitaires de France, 1998, p. 85-119, but also W. Hübener, "*Scientia de aliquo et nihilo*. Die historischen Voraussetzungen von Leibniz' Ontologiebegriff", in Id., *Zum Geist der Prämoderne*, Würzburg, Königshausen-Neumann, 1985, p. 84-100 and G. Mormino, "La limitazione originaria delle creature in Leibniz", in d'Ippolito, Montano, Piro (ed.), *Monadi e monadologie*, p. 115-140.

[18] G. W. Leibniz, "Dialogue effectif sur la liberté de l'homme et l'origine du mal", in Id., *Dialoghi filosofici e scientifici*, ed. F. Piro, Milano, Bompiani, 2007, p. 320.

[19] Leibniz, *Sämtliche Schriften und Briefe*, II-3B, p. 426-427.

The same reasoning is also present in the famous *Explication de l'arithmetique binaire*, written in 1703, were Leibniz adds that:

> le calcul par deux, c'est à-dire par 0 et par 1, en récompense de sa longueur, est le plus fondamental pour la science, et donne de nouvelles découvertes, qui se trouvent utiles ensuite, même pour la pratique des nombres, et surtout pour la Géométrie, dont la raison est que les nombres étant reduits aux plus simples principes, comme 0 et 1, il paroit partout un ordre merveilleux.[20]

These quotes show that the metaphysical background of Leibniz's binary arithmetic was consistent throughout his life. This is relevant, since the first work on this topic, *De organo sive arte magna cogitandi*, was written in 1679: it means that these metaphysical assumptions were maintained despite the well-known change in Leibniz's philosophy happened in the 1680's. The previously quoted letter to Schulenburg is perhaps the best evidence of this consistency, because the philosophical achievements of binary arithmetic are expressed together with Leibniz's new discoveries on the nature of substances.[21]

Regarding our purpose of determining a possible influence of Weigel's *De supputatione* on Leibniz's *De organo*, the reference to Leibniz's writings after 1679 was needed in order to point out how the comparison with unity, God and nothingness was considered by Leibniz a distinctive feature of his base-two model, especially with respect to Weigel's solution. The same reasoning in fact is found in the *Animadversiones ad Weigelium*,[22] although here expressed in order to state the superiority of Leibniz's system from that of Weigel. It is as if Leibniz himself wanted to divert the attention from the metaphysical background to the idea of changing the base of counting. In a way, he achieved this result, since both Couturat's and Grua's reconstruction of the birth of the binary calculus are based on the assumption that, if there was some kind of influence by Weigel, it had to be only in the mathematical aspect. This theory should be rejected judging by what I believe is, in reference to the intercourse between Weigel and Leibniz, the most important quote from Weigel's *De supputatione*:

> Principium nempe finitatis, ipsiusque multitudinis & ordinis est, quod hinc, etiam in computatione primum, ubique praesupponitur. Estque conceptu suo vel *purum*, quod est NULLITAS, τὸ *Nihil*, purae computationis (*Additionis, Subctrationis*) principium; vel *modale* seu mensurativum, quod est τὸ *Semel*, aut simplum, modalis

[20] Leibniz, *Leibnizes mathematische Schriften*, vol. VII, p. 225.
[21] Leibniz, *Sämtliche Schriften und Briefe*, II-3B, p. 427.
[22] Leibniz, *Nouvelles lettres*, p. 166.

computationis (*Multiplicationis, Divisionis*) principium : Quatuor haec (*principium*, bina *data*, *productum* seu τό Facit) exacta proportione sui generis progrediuntur, dum in omni computo, sicut se principium ad datorum unum habet.[23]

In order to understand this quote, a look at the very beginning of *De supputatione* is needed. Here, some universal rules are set:

I. Omnia quae realiter (i.e. actu) sunt, singularia sunt.
II. Omnes Actiones reales circa singularia sunt.
III. Omia singularia finita Valorem in se complectuntur *Pondere, Mensura, Numero*, sed & *Ordine*, certum; inter se certa *Ratione* certaque *Proportione* definita sunt.
IV. Omnes agendo circa res occupati Supputant".[24]

According to Weigel, everything in this world can be conceived as a unity. This possibility deprives every object of their specific proprieties, but at the same time it makes them homogeneous one another, that is suitable for a mathematical description. The first quote then shows that every finite object conceived this way is a single entity composed of nothingness and unity. In Weigel's philosophy in fact, the word *Semel* stands for unity or God, because it is a reference to the most important operation related to divinity, that is multiplication. It is extremely relevant because, unlike a generic platonic reference to non-existence, these universal principles are associated with mathematical operations. The idea is that God represents pure unity, while creatures represent compositions of unity and nothingness, that is zero. The expression of God's infinity is multiplication, because the multiplication 1 x 1, while it could be executed indefinitely, still gives as a result the pure unity. God then embeds the whole world, that is the product of all its finite unities, from nothingness to pure infinity, as the complete title of *De supputatione* suggests. It follows that addition and subtraction are considered in a negative way, thus associated with nothingness: addition and subtraction force things to come into existence as separate things, because they free them from the logic of unities' multiplications. Given these premises, Weigel adds a fundamental consequence:

[23] E. Weigel, *De supputatione multitudinis a nullitate per unitates finitas in infinitum collineantis ad deum quavis demonstratione certius, ostendendum reflexa, publice disputabunt præses Erhardus Weigelius ... et respondens Caspar Bussingius*, Jena, Typis Bauhoferianis, 1679, part I, § 29. I'm quoting this work by using the reference to its parts and chapters. Weigel's *De supputatione* in fact was published with no page numbers until part III, making the reference to a specific page confusing for the reader.

[24] Weigel, *De supputatione*, Preface.

> Sicut autem primum omnium Veritatum principium [...] *est Veritas* infinita, DEUS; Objectivum autem NULLITAS qua puram; UNITAS finita (simplicissime punctum) qua modalem, finitorum rationem; ita TETRACTYS ab utroque principio, per quaternitates propotionum, illic purarum, hic modalium.[25]

The *tetractys* then was chosen by Weigel because it shares through proportions a relationship with both unity and nothingness. It is important to remember that, despite the impossibility of proving that Leibniz read the *Tetractys* at this stage, Weigel had already published this work in 1673. Therefore, in 1679's *De supputatione*, while establishing a relation between the Pythagorean *tetractys* and the metaphysical concepts of unity and nothingness, Weigel establishes also a relationship between his base-four arithmetic and these philosophical ideas: "rationes numerorum & ordinum, earumque progressionem quadrordinalem (Tetractyn) secudum quam DEUS in gratiam humanae Mentis omnes Essentias tanta varietatis pulcritudine concinnavit, supputando penetremus".[26] It follows that there is no way of understanding Weigel's influence on Leibniz as a mere suggestion on changing numbering's base model. Weigel was extremely close to binary arithmetic as it was conceived by Leibniz, because every element of it was already present in his works, so much that Leibniz's efforts could be seen as a prosecution of his teacher's work, as Bernulli suggested.

Leibniz's image of the world's creation through unity and nothingness and its mathematical expression then were already present in Weigel, but a possible criticism to this interpretation would be that of arguing for a simple Pythagorean influence, rather than a specific influence by Weigel's Pythagoreanism. Even accepting this criticism, we could remark that before 1679 Leibniz quoted Pythagoras mainly in geometrical writings, for obvious reasons, and together with Plato's writings concerning metempsychosis, but only after April 1679 he is also credited for his metaphysical theories on numbers. The most famous quote is that of *De numeris characteristicis ad linguam universalem constituendam*, again in 1679:

> Vetus verbum est, Deum omnia pondere, mensura, numero fecisse. Sunt autem quae ponderari non possunt, scilicet quae vim ac potentiam nullam habent; sunt etiam quae carent partibus ac proinde mensuram non recipiunt. Sed nihil est quod numerum non patiatur. Itaque numerus quasi figura quaedam metaphysica est, et Arithmetica est quaedam Statica Universi, qua rerum gradus explorantur. Jam inde a

[25] Ibid., part I, § 27.
[26] Ibid., part III, § 20.

> Pythagora persuasi fuerunt homines, maxima in numeris mysteria latere. Et Pythagoram credibile est, ut alia multa, ita hanc quoque opinionem ex Oriente attulisse in Graeciam.[27]

Almost every information displayed here could be retraced in Weigel's *De supputatione*, from the famous partition in "*pondere, mensura, numero*"[28] to the less famous use of the metaphysical number, making him at least the major influence in the adoption of Pythagorean theories.[29]

Particularly interesting is the way in which Leibniz defines arithmetic related to the description of the world as a *Statica Universi*. This term suggests the idea that arithmetic could offer us a kind of static description of the world, but this idea is not consistent with the basic notion we have about arithmetic: if this description involves the use of arithmetical operations, it cannot be based solely on them, because the world is shaped in a different way than that of numbers. Both are well-ordered systems, but the relationship between things in our world need some kind of spatial reference that numbers *per se* don't need. This order is expressed in Weigel by the notion of *Status*. Again, the reference to Weigel could help in explaining Leibniz's theory. As we previously sketched, in Weigel's philosophy every entity is conceived as a unity, making it suitable for mathematical operations. However, the existence of our world and the possibility of knowing it is not based solely on arithmetic, but on the study of the relational proprieties[30] and positions of such unities:

> Cujus & totius, & cujusque partis, ut numeri partialis, unitates ORDINE *certo*, simul ac numerantur, etiam disponuntur a DEO, tum *simul*, & Ordo dicitur *Status*; tum secundum prius & posterius, & Ordo dicitur *Motus*.[31]

For Weigel, *Status* is the set of relationships between unities that give birth to the world in an instant, while *Motus* is the connection of these instantaneous descriptions of the world in time. In other words, they are Weigel's equivalent of space and time, as he himself writes in his first reply to Leibniz's 1679 letter:

[27] Leibniz, *Sämtliche Schriften und Briefe*, VI-4A, p. 263.

[28] A part from the already quoted preface, see also Weigel, *De supputatione*, part I, § 36 and part III, § 22.

[29] "Mirum non est, quod TETRACTYS a Pythagoraeis adeo celebrata" (ibid., part I, § 27).

[30] "Actiones enim rebus singularibus intercedunt, quae certa ratone (valoris & ordinis) inter se, tum essentialiter, quoad rationem status; tum accidentaliter quoad certos in operando casus & circumstantias, proportionatae sunt: ipsa vero proportio non nisi computando definiri potest" (ibid., part I, § 21).

[31] Ibid., part II, § 17.

> Spatium (sc. ubicativum, i.e. rerum juxta se mutuo simul existentium non-repugnantia loco nihili,rerumque concepta) et Tempus in abstracto (tanquam Spatium quandicativum,i.e. rerum omnium, ut unius copiae, secundum prius et posterius existentium i.e. repetitarum, non-repugnantia loco nihili rerumque concepta) tanto magis analoga sunt inter se, quanto praecisius utrumque dicit potentiam perceptibilis positionis, illud simultaneae hoc successivae.[32]

This reference could explain, with regards to the development of Leibniz's philosophy, how binary arithmetic fits in 1679's renewed interest in logic[33] and *analysis situs*.

Another important resemblance between Weigel's *De supputatione* and Leibniz's *De organo* pointing in this direction is found at the starting point of the reasoning leading to the binary system in *De organo*: for a theory that claims the possibility of describing the whole world through a peculiar way of expressing numbers and their operations, it seems unusual that the first step in this direction would be an analysis of the relationship between the world and the human mind. We would be inclined to think in fact that such description of the world would be a sort of objective description, since it's based on purely mathematical assumptions. In this work however, before the introduction of the binary system, Leibniz reflects on the idea of conceivability:

> Maximum Menti Remedium est si inveniri possint cogitationes paucae, ex quibus exurgant ordine cogitationes aliae infinitae. Quemadmodum ex paucis numeris ab unitate usque ad denarium sumtis caeteri omnes numeri ordine derivari possunt. Quicquid cogitatur a nobis aut per se concipitur, aut alterius conceptum involvit. Quicquid in alterius conceptu involvitur id rursus vel per se concipitur vel alterius conceptum involvit [...] Tametsi infinita sint quae concipiuntur, possibile tamen est pauca esse quae per se concipiuntur. Nam per paucorum combinationem infinita componi possunt.[34]

Many ideas expressed in this brief passage date back to Leibniz's early years, although here they will be later connected with the binary system. The first idea expressed is a minimalistic approach to universal principles. The

[32] Leibniz, *Sämtliche Schriften und Briefe*, II-1B, p. 762.

[33] Leibniz kept the connection between logic and binary arithmetic also in later writings. For example in the *Explication de l'arithmetique binaire*, after introducing his calculus, we read: "Cependant je ne sçai s'il y a jamais eu dans l'écriture Chinoise un avantage approchant de celui qui doit être nécessairement dans une Caractéristique que je projette. C'est que tout raisonnement qu'on peut tirer des notions, pourroit être tiré de leurs Caractères par une manière de calcul, qui seroit un des plus importans mo yens d'aider l'esprit humain" (Leibniz, *Leibnizes mathematische Schriften*, vol. VII, p. 227).

[34] Leibniz, *Sämtliche Schriften und Briefe*, VI-4A, p. 157-158.

relationship between the number of universal principles chosen and the number of things that they are able to explain should always aim for the smallest number of principles and the highest number of things explained by them. Leibniz extensively used this idea, for example when he uses the principle of contradiction, and I believe it can be proved that a decisive influence in its adoption is again that of Weigel, especially between 1663 and 1672, when Leibniz read his *Analysis Aristotelica ex Euclide restituta*. For our proposes it is sufficient to say that in *De organo* this minimalistic yet fertile approach is connected with numbers and their relationships. A passage of Weigel's *De supputatione* outlines a similar approach on universal principles: "Directorii vero f. Normae moralis, naturaliter & ordinarie ducentis, officio funguntur Notitia primae nobiscum nata, quae dicuntur Axiomata (v.g. Semel unum est unum etiamsi sit infinitum : Finis rei [terminus & limes rei] nihil est prater cogitationem : Finitorum autem Bis unum sunt duo : Totum sua parte majus est)".[35] For Weigel, the universal principles residing in the human mind are the ones that allow the foundation of arithmetic, such as the idea of multiplication, the idea of addition and the idea that the whole is bigger than its part. At first it wouldn't seem as if Leibniz's reasoning in *De organo* has any kind of reference to universal principles. But we should remember that for Leibniz, at least after 1672's *Confessio philosophi*, conceivability involves non-contradiction, since in that work he establishes a bond between the concept of possibility and the act of conceiving, founding both on the principle of contradiction. If conceivability is presented through the principle of contradiction, then Leibniz's reasoning is not that far from his mathematics as it may seem: the reader accustomed to these topics in fact should recognize that these principles, together with the idea that they reside in the human mind, are the ones that Leibniz uses in his foundation of arithmetic. At the end of his life, in the *Initia rerum mathematicarum metaphysica*, Leibniz gives us the best example of this foundation, that involves the principle of the whole as a coherence tool in order to identify the correct order between numbers, exemplified in the relationships given in his geometrical *analysis situs*. The principle for which the whole is always bigger than its part is demonstrated by Leibniz using again the principle of contradiction or identity,[36] justifying his famous idea that the whole of

[35] Weigel, *De supputatione*, part I, § 11.

[36] "Unde videmus demonstrationes ultimum resolvi in duo indemonstrabilia: Definitiones seu ideas, et propositiones primitivas, nempe identicas, qualis haec est B est B,

mathematics could be derived from this principle. The start of this challenging project is Leibniz's 1679 *Characteristica geometrica*, coeval with his writings on binary arithmetic and with his renewed efforts on the universal characteristic.

Weigel's *De supputatione* starts in the same way of Leibniz's *De organo*, establishing complete homogeneity between the world and the human mind:

> Unusquisque nostrum, etiamsi solus sit, *simul* ac de semetipso cogitat (dum secum habitat) Semetipsum illico familiariter agnoscit: idque (1) *Ratione* STATUS [...] (2) *Ratione* MOTUS [...] ex Identitate cogitationis suae successivae clarissime deducit, se posterius in essendo praesentem, *eundem esse qui*, prius in essendo praesens, *erat.*[37]

Here Weigel argues, following probably Descartes' method, that, even if we were completely deprived of our experiences, in our minds is contained everything we need not only to understand but also to express the whole world. The very simple act of perceiving unity and its constant perception in time give birth to the subjective representation of *Status* and *Motus*, that is space and time. This is possible because of the universal principles residing in human minds:[38] unity, addition, multiplication and the principle for which the whole is bigger than its part, that is *Ordo*, are the same elements that we already saw in the objective description of the world. Once corroborated by experiences, these principles show the homogeneity between men and the world:

> Axiomatum, ut generalium principiorum, suscitabula sunt *Experientiae*, tum *immediata*, Mentis ipsius per se v. g. *Mentem hominis* in *Ubi* per corpus suum & ipsius Mundi *definito contineri* [...] tum *mediata*, Mentis per sensus, h.e. per oblationem ad adjuncto sibi corpore factam, obsevabiles, v.g. *Res Mundi circa Nos vario Status & Motus variabilis ordine disponi.*[39]

There are several similarities between these passages and Leibniz's idea of truth expressed through relations, both in understanding truth for things that already exist, like in 1677's *Dialogus*, or in discovering new ones, as in

unumquodque sibi ipsi aequale est, aliaequale hujusmodi infinitae" (Leibniz, *Leibnizes mathematische Schriften*, VII, p. 20)

[37] Weigel, *De supputatione*, part I, § 1.

[38] "Notitias illas, ut Mentis alias tenebricolae luculas (scintillulas) principia, rationes, & causas Mentaliter operandi primas; una cum immediatis experientiis, quisque nostrum simpliciter & indubie Semper novit, intime perspectas habet, intelligit, atque sapit" (ibid., § 13).

[39] Ibid., § 12.

the *ars inveniendi.*[40] The homogeneity between the universal principles instead will be crucial in Leibniz's *Nouveaux Essais sur l'entendement humain*.

As a final remark for this section, I would like to add that the first quote of Weigel's *De supputatione* here presented could again suggest that Leibniz read this work around the time of his *De organo*: in Weigel, the two universal principles are introduced as "τὸ *Nihil*" and "τὸ *Semel*". We could say that the use of the ancient Greek's definite article is a distinctive trait of Weigel's writing, used in every work ever published. He uses Latin in metaphysical essays, while adding German in order to express examples or specimina and Greek for the most important principles of his philosophy. The definite article is his way of promoting a concept to a universal principle, much like his use of italics or small capitals. This peculiar way of writing is not present in Leibniz in the years before 1679, but it suddenly appears for the first time in April and vanishes around the end of that summer,[41] that is the period of time between Leibniz's *De organo* and his first letter to Weigel. Leibniz adopted this trait and I believe that this could be an interesting hint on the exact moment in which Leibniz received Weigel's work, because it is based on a specific pattern, and not on a generic use of ancient Greek, very frequent in these kind of writings.

4. *Conclusion*

After having analysed Weigel's influence, the remaining task is understanding why Leibniz tried to hide it throughout his life. The obvious conclusion seems to be that Weigel's theory was too similar to that of Leibniz and admitting its influence would have led to a charge of plagiarism, but I believe that in Leibniz's attitude there is more than just fear. In 1679, after his stay in Paris, Leibniz achieved a superior

[40] Weigel has his own *ars inveniendi*, called at times *deductio productionalis* or *inventio*: "Exserit autem se computus per SCISCITATIONEM & INVENTIONEM [...] *qua ratio latens inter ipsas rationes illi conjugatas quaeritur & inventa producitur*. Μανθάνω enim, latine *sciscitare*, non est receptas sententias discere, quaerentique verbaliter, i.e. interroganti, recitare [...] sed *ignotas Veritates cum judicio rimari, tandemque* si Veritatum Autor annuat *producere*: non ex nihilo, sed *ex datis* positisque certis veritatibus & rationibus" (ibid., § 22).

[41] The first use is a "το *non-fortunatum*" in the *Calculus consequentarum*, written in April 1679 (Leibniz, *Sämtliche Schriften und Briefe*, VI-4A, p. 223). Then we find it in *De negatione* (Summer 1679, Leibniz, *Sämtliche Schriften und Briefe*, VI-4A, p. 300) and in the *Potest aliqua notio esse alia generalior ut tamen non sit simplicior* (Spring – Summer 1679, Leibniz, *Sämtliche Schriften und Briefe*, VI-4A, p. 303).

mathematical knowledge, unknown to Weigel, that affects their different ways of conceiving arithmetic. While in Weigel's *De supputatione* the relationship between the finite and the infinite is standard – God is the expression of the infinite, creatures are the expression of the finite – Leibniz had to deal with his recent discoveries on the infinitesimal calculus. If both binary arithmetic and the infinitesimal calculus were to be applied to an indefinitely divisible world, the problem of dealing with infinity arises in a much more complicated way than that of Weigel. Leibniz remarks this in the *Animadversiones ad Weigelium*:

> Scientia de quantitate in universum vel de aestimatione, ut vocat celeberrimus Weigelius, mihi pro dimida tantum parte tradita videtur. Exstat enim ea tantum pars quae finitas quantitates versat; sed restabat matheseos generalis pars sublimior, ipsa scilicet Scientia infiniti saepe ad finitas ipsas investigandas necessaria, quam fortasse primus analyticis praeceptis adornavi, novo etiam calculi genere proposito, quem nuncegregii viri passim adhibent.[42]

Leibniz believed that his binary arithmetic could express a better image of the world than Weigel's calculus. This belief probably explains why Leibniz's first letter to Weigel, instead of reporting the analogies with his calculus, deals mainly with the problem of infinity. It is as if Leibniz wanted to show to his former teacher his superior mathematical expertise by analysing the differences between infinite series[43] and, consequently, showing that he was more apt to pursue the objectives of the metaphysical arithmetic. Weigel's reply to these remarks shows in fact this fundamental difference: "Infinitum enim definiri contradictionem implicat, hinc ipsum medium vel quasi nempe $\frac{1}{0}$ i.e. unum nihil, indefinitum est",[44] encouraging Leibniz in reserving this task to himself. Having analysed Weigel's influence however, a better understanding of Leibniz's aim is possible. He believes that binary arithmetic is an appropriate expression of an infinite world because, as we saw in Weigel, its description is based on the study of relational proprieties, more than arithmetic operations. In this regard, the

[42] G. W. Leibniz, *Textes inédits*, p. 148.

[43] "At summa seriei hujus infinitae $\frac{1}{2}\ \frac{1}{3}\ \frac{1}{4}\ \frac{1}{5}$ etc. Est $\frac{1}{0}$ quae quantitas est infinita, major scilicet quovis numero assignabili, quemadmodum etiam demonstrare possum. Interim multo imo infinities minor est quam summa seriei hujus $\frac{1}{1}\ \frac{1}{1}\ \frac{1}{1}\ \frac{1}{1}$ etc. Vides itaque inter illud infinitum ordinarium, quod in omnium unitatum collectione consistit, et inter finitum, nempe unitatem, dari aliquid intermedium nempe $\frac{1}{0}$ quod est summa fractionum omnium possibilium numericarum, unitatem pro numeratore habentium, simul sumtarum" (Leibniz, *Sämtliche Schriften und Briefe*, II-1B, p. 745).

[44] Leibniz, *Sämtliche Schriften und Briefe*, II-1B, p. 762.

binary system is nothing more than a way of labelling things, much like names or characters. Its advantages are that instead of names, it uses only two digits, connected in a way that allows, at the same time, the possibility of naming things indefinitely and the creation of names that are always distinguishable between themselves. However, the fact that order is derived solely from the notion of *Status* is also the most important limit of Leibniz's binary arithmetic: the arithmetical operations lose a distinctive role, meaning that a connection between the wonderful proprieties that Leibniz saw studying the binary series in artihmetics are not coherently related to the use of the binary system in metaphysics. This difference explains why Leibniz refers often to the idea of an analogy between binary arithmetic and the world, rather than an exact expression. Despite these difficulties, Leibniz was probably afraid that the reference to Weigel would have diverted the attention from what he believed was a better explanation of how binary calculus is useful in dealing with an infinite reality.

Another reason why Leibniz was not inclined in recognising Weigel's influence is the main metaphysical consequence of a purely mathematical description of the world: if unity is what describes the entire world, then the difference between God and creatures is at stake. If for Weigel the main difference is only that "*infinitam* dari *Mentem,* a qua Mentes finitae Mensuram capiant",[45] it follows that the universal principles are shared between God and his creations. The result is not only that God as the *Computator* acts in the same way of creatures, only with an infinite mind, but also that the finite is contained in the infinite through the use of multiplication: "ENS REALE vel *infinitum* est & PRIMUM, DEUS, in quo vivimus & movemur".[46] Judging by this quote, it comes as no suprise that in the same year Weigel was forced to retract one of his works by the faculty of theology. Leibniz was interested in this topic and in Weigel's demonstration of God's existence[47] and maybe this awareness explains the need of expressing a criticism to Spinoza in Leibniz's letter to Schulenburg about binary arithmetic.[48]

In conclusion, despite these possible explanations of his cautiousness, Leibniz was interested in Weigel's philosophy throughout his whole life. It is now clear that since its beginnings Leibniz's mathematics was influenced

[45] Weigel, *De supputatione*, part I, § 10.

[46] Ibid., part III, § 26.

[47] See S. Di Bella, *The Science of the Individual: Leibniz's Ontology of Individual Substance*, Dordrecht, Springer, 2010, p. 260-261.

[48] Leibniz, *Sämtliche Schriften und Briefe*, II-3B, p. 427.

by Weigel on many topics: from the terminology adopted and the reference to the Pythagorean tradition to the use of a different base-model, its connection with unity and nothingness by means of arithmetical operations, and the homogeneity among logical principles in a relational description of the world. In 1679 this exchange of ideas gave birth to binary arithmetic.

REFERENCES:

Antognazza, Maria Rosa, *Leibniz: an intellectual biography*, Cambridge, Cambridge University Press, 2009.

Arthur, Richard T. W., "Leibniz's theory of space", *Foundations of science: the official journal of the Association for Foundations of Science, Language and Cognition*, 18 (3), 2013, p. 499-528.

Bullynck, Maarten, "Erhard Weigel's Contributions to the Formation of Symbolic Logic", *History and Philosophy of Logic*, 34 (1), 2013, p. 25-34.

Cook, Daniel J., "Leibniz on creation, binary arithmetic and the Yi-Jing", in *Nihil sine ratione: Mensch, Natur und Technik im Wirken von G. W. Leibniz; VII. Internationaler Leibniz-Kongreß, [Berlin, 10-14 September 2001]*, Hannover, Gottfried-Wilhelm-Leibniz-Gesellschaft, 2001, p. 237-244.

Couturat, Louis, *La logique de Leibniz: d'apres des documents inédits*, Paris, F. Alcan, 1901.

De Risi, Vincenzo, *Geometry and Monadology. Leibniz's Analysis Situs and Philosophy of Space*, Basel, Birkhäuser, 2007.

Di Bella, Stefano, *The Science of the Individual: Leibniz's Ontology of Individual Substance*, Dordrecht, Springer, 2010.

Fichant, Michel, "L'origine de la négation", in Michel Fichant, *Science et métaphysique dans Descartes et Leibniz*, Paris, Presses Universitaires de France, 1998.

Glaser, Anton, *History of binary and other nondecimal numeration*, Pennsylvania, Tomash Publishers, 1981.

Habermann, Katharina-Herbst, Klaus-Dieter (ed.), *Erhard Weigel (1625-1699) und seine Schüler. Beiträge des 7. Erhard-Weigel-Kolloquiums 2014*, Göttingen, Universitätsverlag Göttingen 2016.

Hübener, Wolfgang, "*Scientia de aliquo et nihilo*. Die historischen Voraussetzungen von Leibniz' Ontologiebegriff", in Wolfgang Hübener, *Zum Geist der Prämoderne*, Würzburg, Königshausen-Neumann, 1985, p. 84-100.

Knecht, H. H., *La logique chez Leibniz. Essai sur le rationalisme baroque*, Lausanne, L'Age d'Homme, 1981.

Leibniz, Gottfried Wilhelm, *Nouvelles lettres et opuscules inédits de Leibniz*, ed. A. Foucher de Careil, Paris, 1857.

Leibniz, Gottfried Wilhelm, *Sämtliche Schriften und Briefe*, Darmstadt-Leipzig-Berlin, Akademie der Wissenschaften (Akademieausgabe), 1923-.

Leibniz, Gottfried Wilhelm, *Textes inédits d'après les manuscrits de la Bibliothèque provinciale de Hanovre*, ed. G. Grua, Paris, Presses Universitaires de France, 1948.

Leibniz, Gottfried Wilhelm, *Leibnizes mathematische Schriften*, ed. C. I. Gerhardt, Hildesheim-New York, Georg Olms Verlag, 1971.

Leibniz, Gottfried Wilhelm, *Dialoghi filosofici e scientifici*, ed. F. Piro, Milano, Bompiani, 2007.

Mercer, Christia, *Leibniz's Metaphysics: Its Origins and Development*, Cambridge, Cambridge University Press, 2002.

Moll, Konrad, *Der junge Leibniz, Bd. I: Die wissenschaftstheoretische Problemstellung seines ersten Systementwurf. Der Anschluss an Erhard Weigel*, Stuttgart-Bad, Frommann-Holzboog, 1978.

Mormino, Gianfranco, "La limitazione originaria delle creature in Leibniz", in B. M. d'Ippolito, A. Montano, F. Piro (ed.), *Monadi e monadologie. Il mondo degli individui tra Bruno, Leibniz e Husserl. Atti del Convegno Internazionale di Studi [Salerno, 10-12 giugno 2004]*, Soveria Mannelli, Rubbettino Editore, 2005.

Palumbo, Margherita, "'Praeceptor, Fautorque meus colendus…' – Weigels Werke in der Privatbibliothek von Leibniz", in K. Habermann-K. D. Herbst (ed.), *Erhard Weigel (1625-1699) und seine Schüler. Beiträge des 7. Erhard-Weigel-Kolloquiums 2014*, Göttingen, Universitätsverlag Göttingen 2016, p. 249-268.

Pasini, Enrico, "La philosophie des mathématiques chez Leibniz: lignes d'investigation", in *Nihil sine ratione: Mensch, Natur und Technik im Wirken von G. W. Leibniz; VII. Internationaler Leibniz-Kongreß, [Berlin, 10. - 14. September 2001]*, Hannover, Gottfried-Wilhelm-Leibniz-Gesellschaft, 2001, p. 954-963.

Piro, Francesco, *Varietas identitate compensata: studio sulla formazione metafisica di Leibniz*, Napoli, Bibliopolis, 1990.

Piro, Francesco, "*Species infima*. Definibilità e indefinibilità dell'individuo", in B. M. d'Ippolito, A. Montano, F. Piro (ed.), *Monadi e monadologie. Il mondo degli individui tra Bruno, Leibniz e Husserl. Atti del Convegno Internazionale di Studi [Salerno, 10-12 giugno 2004]*, Soveria Mannelli, Rubbettino Editore, 2005.

Shirley, John W., "Binary numeration before Leibniz", *American Journal of Physics: a Publication of the American Association of Physics Teachers*, 19, 1951, p. 452-454.

Weigel, Erhard, *Idea matheseos universae*, Jena, Typis & sumptibus Johannis Jacobi Bauhoferi, 1669.

Weigel, Erhard, *Tetractyn Pythagoreae corrspondentem ut PRIMUM disceptationum suarum specimen ulteriori curiosorum industria exponit Societas Pythagorea*, Typis Wertherianis, 1672-73.

Weigel, Erhard, *Tetractys summum tum arithmeticae tum philosophiae discursivae compendium, artis mangnae sciendi genuina radix*, Jena, Sumptibus Johannis Meyeri, Typis Wertheriani, 1673.

Weigel, Erhard, *Corporis pansophici pantologia*, Jena, Literis Johannis Jacobi Bauhoferi, 1673.

Weigel, Erhard, *Pendulum ex tetracy deductum…sistit*, Jena, Typis Johannis Wertheri, 1674.

Weigel, Erhard, *De supputatione multitudinis a nullitate per unitates finitas in infinitum collineantis ad deum quavis demonstratione certius, ostendendum reflexa, publice disputabunt præses Erhardus Weigelius … et respondens Caspar Bussingius*, Jena, Typis Bauhoferianis, 1679.

Weigel, Erhard, *Aretologistica*, Nürnberg, Bey Wolffgang Moritz Endtern, 1687.

Weigel, Erhard, *Werke*, Stuttgart- Bad Cannstatt, Fromman-Holzboog, 2003-.

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